# 13. Assessment of the Northern Rockfish stock in the Bering Sea/Aleutian Islands

by

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## Executive Summary

The last full assessment for northern rockfish was presented to the Plan Team in 2021. The following changes were made to northern rockfish assessment relative to the November 2021 SAFE:

### Summary of Changes in Assessment Inputs

Changes in the input data:

1) Catch data was updated through 2022, and total catch for 2023 was projected.
2) The 2022 Aleutian Island survey age composition, the 2021 fishery age composition data, and the 2022 fishery length composition data were included in the assessment.
3) The 2022 Aleutian Island survey biomass estimate was included in the assessment.
4) The ageing error matrix was updated.

Changes in the Assessment Methodology

1) There were no changes to the assessment methodology.

### Summary of Results

BSAI northern rockfish are not overfished or approaching an overfished condition. The recommended 2024 ABC and OFL are 19,274 t and 23,556 t, which are 3% increases from the values specified last year for 2023 of 18,687 t and 22,776 t. The reason for the increase in the harvest level is an increase in the 2022 survey biomass estimate relative to previous survey years.

The Risk Table categories have been altered for 2023, with the category of "substantial concern" being eliminated. Our evaluation of the risks for this assessment is below:

| *Assessment-related considerations* | *Population dynamics considerations* | *Environmental/ ecosystem considerations* | *Fishery Performance considerations* | *Overall score (highest of the individual scores)* |
|---|---|---|---|---|
| Level 2: Major Concern | Level 2: Major Concern | Level 1: No Concern | Level 1: No Concern | Level 2: Major Concern |

The assessment –related concerns relate to the retrospective pattern in the assessment, and the use of strong priors for several key model parameters that cannot be reliably estimated (in effect understating the level of uncertainty in the assessment). A population dynamics concern is that the spatial management of the stock is not consistent with the genetic spatial structure, which could lead to subarea depletion and loss of fishery yield, particularly as the target fishery for northern rockfish is developing.

The concerns identified above are not addressed in the assessment and Tier status for this stock. Issues such as the retrospective pattern and the use of strong prior distributions affect the results of the assessment, but are not mitigated or otherwise addressed within the assessment. These factors are also not addressed by our current Tier system. Additionally, the mismatch between the genetic spatial structure and the spatial management of the stock is also not addressed within the assessment or the Tier system, as this issues extends beyond the assessment itself.

Overall, the stock abundance is high and the exploitation rates are low. Given the current stock status, we recommend the full ABC.

A summary of the recommended ABCs and OFLs from this assessment relative the ABC and OFL specified last year is shown below:

| | As estimated or specified last year for: | | As estimated or recommended this year for: | |
|---|---|---|---|---|
| **Quantity** | 2023 | 2024 | 2024* | 2025* |
| *M* (natural mortality rate) | 0.054 | 0.054 | 0.052 | 0.052 |
| Tier | 3a | 3a | 3a | 3a |
| Projected total (age 3+) biomass (t) | 277,133 | 273,414 | 297,189 | 292,686 |
| Female spawning biomass (t) | | | | |
| Projected | 118,251 | 115,209 | 128,229 | 124,651 |
| $B_{100\%}$ | 171,768 | 171,768 | 187,268 | 187,268 |
| $B_{40\%}$ | 68,707 | 68,707 | 74,907 | 74,907 |
| $B_{35\%}$ | 60,119 | 60,119 | 65,544 | 65,544 |
| $F_{OFL}$ | 0.085 | 0.085 | 0.086 | 0.085 |
| $maxF_{ABC}$ | 0.069 | 0.069 | 0.070 | 0.069 |
| $F_{ABC}$ | 0.069 | 0.069 | 0.070 | 0.069 |
| OFL (t) | 22,776 | 22,105 | 23,556 | 22,838 |
| maxABC (t) | 18,687 | 18,135 | 19,274 | 18,685 |
| ABC (t) | 18,687 | 18,135 | 19,274 | 18,685 |
| **Status** | As determined last year for: for: | | As determined this year | |
| | 2021 | 2022 | 2022 | 2023 |
| Overfishing | No | n/a | No | n/a |
| Overfished | n/a | No | n/a | No |
| Approaching overfished | n/a | No | n/a | No |

*Projections are based on estimated catches of 8,494 t and 8,234 t used in place of maximum permissible ABC for 2024 and 2025. Fishing and biomass reference points (i.e., max $F_{abc}$, $F_{ofl}$, and $B_{x\%}$) are based on estimated average population and fishery sizes-at-age from 2019-2023.

## Summaries for the Plan Team

The following table gives the recent biomass estimates, catch, and harvest specifications, and projected biomass, OFL and ABC for 2022-2025.

| Year | Biomass (ages 3+)[1] | OFL | ABC | TAC | Catch[2] |
|---|---|---|---|---|---|
| 2022 | 279,584 | 23,420 | 19,217 | 17,000 | 7,898 |
| 2023 | 277,133 | 22,776 | 18,687 | 11,000 | 9,948 |
| 2024 | 297,189 | 23,556 | 19,274 | | |
| 2025 | 292,686 | 22,838 | 18,685 | | |

[1] Total biomass from age-structured projection model.
[2] Catch as of September 16, 2023.

## Responses to SSC and Plan Team Comments on Assessments in General

SSC (June, 2021) *The SSC supports the recommendation of reducing the number of category levels from four to three.*

The number of category levels for the risk table was reduced from 4 to 3 in this assessment.

SSC (October, 2023) *When there are time-varying biological and fishery parameters in the model, the SSC requests that a table be included in the SAFE that documents how reference points are calculated.*

A footnote was added to the Executive Summary table noting that the reference points were based on the recent 5-year averages of population and fishery size at age.

## Responses to SSC and Plan Team Comments Specific to this Assessment

SSC (December, 2021) *The SSC suggests the technical description of the model (e.g., equations etc.) be moved to an appendix in this assessment, and the main document should contain a detailed text description of the model structure.*

The text includes a streamlined description of the model, with lists of model equations included as assessment tables.

SSC (December, 2021*)  Finally, as the SSC reiterates its request that the aging error matrix be updated with data from the BSAI, as the assessment author did not have time to complete the request this cycle.*

The ageing error matrix has been updated in this assessment.

SSC (December, 2021) *It would also be helpful to confirm the absence of northern rockfish in the EBS survey data, noting the increase in the portion of the AI survey that enters the southern Bering Sea in 2018, following the marine heatwave.*

A table of recent biomass estimates of northern rockfish from the EBS shelf survey is shown below.

| Year | Total Hauls | Hauls with Northern Rockfish Catch | Biomass Estimate (t) | CV of Biomass Estimate |
|---|---|---|---|---|
| 2003 | 376 | 5 | 1531 | 0.79 |
| 2004 | 375 | 0 | 0 | NA |
| 2005 | 373 | 2 | 62 | 0.69 |
| 2006 | 376 | 3 | 186 | 0.64 |
| 2007 | 376 | 1 | 5853 | 1.00 |
| 2008 | 375 | 1 | 580 | 1.00 |
| 2009 | 376 | 2 | 169 | 0.84 |
| 2010 | 376 | 3 | 1116 | 0.91 |
| 2011 | 376 | 5 | 584 | 0.61 |
| 2012 | 376 | 2 | 223 | 0.77 |
| 2013 | 376 | 3 | 538 | 0.90 |
| 2014 | 376 | 2 | 840 | 0.98 |
| 2015 | 376 | 4 | 465 | 0.79 |
| 2016 | 376 | 4 | 115 | 0.50 |
| 2017 | 376 | 4 | 903 | 0.71 |
| 2018 | 376 | 5 | 47946 | 0.96 |
| 2019 | 376 | 4 | 371 | 0.70 |
| 2021 | 376 | 4 | 2281 | 0.93 |
| 2022 | 376 | 10 | 3213 | 0.65 |
| 2023 | 376 | 5 | 456 | 0.57 |

The biomass estimates have not exceed 5,900 t with the exception of 2018, when the estimate was 48,000 t with a CV of 0.96; since 2018, the biomass estimates have not exceeded 3,300 t. Additionally, the number of hauls in which northern rockfish was caught has not exceeded 5 with the exception of 2022 (with 10 hauls). Given the uncertainty in these estimates, the small biomass levels compared to the AI trawl survey, and the limited number of hauls in which northern rockfish were captured, these data were not included in the assessment.

BSAI Plan Team (September, 2023) *The Teams noted the continuing evidence for stock structure and concerns over risks to stock biomass and productivity from disproportionate harvesting. The lack of spatial harvest regulations would not prevent spatially disproportionate harvesting, which has occurred for other BSAI rockfish such as Pacific ocean perch and blackspotted/rougheye rockfish. However, the low rates of harvest for BSAI northern rockfish suggests that this risk has not yet been realized. The Team recommends this information be included in the risk table for the November assessment and that the author and Team continue to monitor this stock for potential spatial concerns.*

SSC (October, 2023) *The SSC supports the BSAI GPT recommendation that the stock structure information be included in the risk table for November and to continue to monitor the stock for potential spatial concerns.*

The information on stock structure and the mismatch between spatial stock structure and spatial management units continues to be included in the Risk Table.

# Introduction

Northern rockfish (*Sebastes polyspinus*) inhabit the outer continental shelf and upper slope regions of the North Pacific Ocean and Bering Sea. Northern rockfish in the Bering Sea/Aleutians Islands (BSAI) region were assessed under Tier 5 of Amendment 56 of the NPFMC BSAI Groundfish FMP until 2004. The reading of archived otoliths from the Aleutian Islands (AI) surveys allowed the development of an age-structured model for northern rockfish beginning in 2003. Since 2004, BSAI northern rockfish have been assessed as a Tier 3 species in the BSAI Groundfish FMP.

## Information on Stock Structure

A stock structure evaluation was included as an appendix to the 2012 stock assessment (Spencer and Ianelli 2012). A variety of types of data were considered, including genetic data, potential barriers to movement, growth differences, and spatial differences in growth and age and size structure.

Several genetic tests were conducted on northern rockfish samples obtained in the 2004 Aleutian Islands and EBS trawl surveys (Gharrett et al. 2012). A total of 499 samples were collected at six locations ranging from the EBS slope to the western Aleutian Islands, and analyses were applied to 11 microsatellite loci. Information on the spatial population structure was obtained from the spatial analysis of molecular variance (SAMOVA; Dupanloup et al. 2002), which identified sets of collections that showed maximum differentiation. Three groups were identified: 1) the eastern Bering Sea; 2) two collections west of Amchitka Pass; and 3) three collections between Amchitka Pass and Unimak Pass. The genetic data also show a statistically significant pattern of isolation by distance, indicating genetic structure being produced from the dispersal of individuals being smaller than the spatial extent of the sampling locations. A range of expected lifetime dispersal distance were estimated, reflecting different assumptions regarding effective population size and migration rates of spawners, and the estimated lifetime dispersal distances did not exceed 250 km. This estimated dispersal distance is comparable to other *Sebastes* species in the north Pacific, which have ranged from 4 to 40 for near shore species such as grass rockfish (Buonaccorsi et al. 2004), brown rockfish (Buonaccorsi et al. 2005), and vermilion rockfish (Hyde and Vetter 2009), and up to 111 km for deeper species such as POP (Palof et al. 2011) and darkblotched rockfish (Gomez-Uchida and Banks 2005). The demographic implication is that movement of fish from birth to reproduction is at a much smaller scale than the geographic scale of the BSAI area. Finally, it is important to recall that the time unit for the estimated dispersal is not years, but generations, and the generation time for northern rockfish is more than 36 years.

Aleutian Island trawl survey data was used to estimate von Bertalanffy growth curves by areas, and show increasing size at age from the western AI to the eastern AI. The largest difference in the growth curves was in the rate parameter *K*, which was smallest in the western Aleutians, indicating that fish in this area approached their asymptotic size more slowly than fish in the EAI and SBS. Additionally, size at age in the GOA is larger than that in the AI, indicating an east-west cline in growth (Clausen and Heifetz 2002)

Spatial differences in age compositions, obtained from the AI trawl surveys from 2002, 2004, and 2006, were evaluated by testing for significant differences in mean age between areas. Significant differences were observed in the mean age between subareas for individual years, but a consistent pattern did not emerge across the years.

Finally, any potential physical limitations to movement were considered. Physical barriers are rare in marine environments, but the Aleutian Islands are unique due to the occurrence of deep passes, typically exceeding 500 m, that may limit the movement of marine biota. For example, Logerwell et al. (2005) identify a "biophysical transition zone" occurs at Samalga Pass. Northern rockfish are a demersal species captured during the AI trawl survey at depths between 100 m and 200 m, so adult rockfish traversing the much deeper AI passes would require greater utilization of pelagic habitats or deeper depths than currently observed in the AI trawl surveys. Movement of larvae between areas is likely a function of ocean currents. On the north side of archipelago, the connection between the east and west Aleutians is limited due to the break associated with Petral Bank and Bowers Ridge, which results in water flowing away from the Aleutian Islands archipelago. On the south side of the Aleutian Islands, the Alaska Stream provides much of the source of the Alaska North Slope Current (ANSC) via flow through Amutka Pass and Amchitka Pass. However, The Alaska Stream separates from the slope west of the Amchitka Pass and forms meanders and eddies, perhaps limiting the connection between the east and west Aleutians.

# Fishery

BSAI foreign and joint venture rockfish catch records from 1977 to 1989 are available from foreign "blend" estimates of total catch by management group, and observed catches from the North Pacific Observer Program database. The foreign catch of BSAI rockfish during this time was largely taken by Japanese trawlers, whereas the joint-venture fisheries involved partnerships with the Republic of Korea. Because northern rockfish were taken as bycatch in the BSAI area, historical foreign catch records have not identified northern rockfish catch by species. Instead, northern rockfish catch has been reported in a variety of categories such as "other species" (1977, 1978), "POP complex" (1979-1985, 1989), and "rockfish without POP" (1986-1988).

Rockfish management categories in the domestic fishery since 1991 have also included multiple species. In 1991, the "other red rockfish" species group was used in both the EBS and AI, but beginning in 1992 northern rockfish in the AI were managed in the "northern/sharpchin" species group. Prior to 2001, northern rockfish were managed with separate ABCs and TACs for the AI and EBS, and in 2001 the two areas were combined into a single management unit under the "sharpchin/northern" species complex. In 2002, sharpchin rockfish (*S. zacentrus*) were dropped from the complex because of their sparse catches, leaving a single-species management category of northern rockfish. The OFLs, ABCs, TACS, and catches by management complex from 1977-2000 are shown in Table 1, and catches from 2001 to present are shown in Table 2.

Since 2002, the blend and catch accounting system (CAS) databases have reported catch of northern rockfish by EBS and AI subareas. From 1991-2001, species catches were reconstructed by computing the harvest proportions within management groups from the North Pacific Foreign Observer Program database, and applying these proportions to the estimated total catch obtained from the NOAA Fisheries Alaska Regional Office "blend" database. This reconstruction was conducted by estimating the northern rockfish catch for each area (i.e., the EBS and each of the three AI areas) and gear type from 1994-2001. For 1991-1993, the Regional Office blend catch data for the Aleutian Islands was not reported by AI subarea, and the AI catch was obtained using the observer harvest proportions by gear type for the entire AI area. Similar procedures were used to reconstruct the estimates of catch by species from the 1977-1989 foreign and joint venture fisheries. Estimated domestic catches in 1990 were obtained from Guttormsen et al. 1992. Catches from the domestic fishery prior to the domestic observer program were obtained from the Pacific Fisheries Information (PACFIN) records.

Catches of northern rockfish since 1977 by area are shown in Table 3. Northern rockfish catch prior to 1990 was small relative to more recent years (with the exception of 1977 and 1978). Harvest data from 2004 -2010 indicates that approximately 88% of the BSAI northern rockfish were harvested in the Atka mackerel (*Pleurogrammus monopterygius*) fishery. Prior to 2011, much of the northern rockfish catch occurred in the western and central Aleutian Islands, reflecting the high proportion of Atka mackerel fishing in these areas (Table 4). However, restrictions on Atka mackerel fishing in the western Aleutians from 2011-2014 constrained the northern rockfish harvest in this area, and during these years the average proportion of northern rockfish harvested in the Atka mackerel fishery declined to 54%. Northern rockfish are patchily distributed and are harvested in relatively few areas within the broad management subareas of the Aleutian Islands, with important fishing grounds being Petral Bank, Sturdevant Rock, south of Amchitka I., and Seguam Pass (Dave Clausen, NMFS-AFSC, personal communication).

Although northern rockfish are generally harvested as a bycatch species, targeting of northern rockfish has occurred in recent years. Observer catch records were used to identify the targeted species of tows, based on the dominant species in the catch. Tows targeting northern rockfish are defined as having rockfish be the largest species group in the catch, and northern rockfish being the most abundant rockfish species. The number of tows targeting northern rockfish increased from 46 in 2014 to 113 in 2015, and this targeting resulted in in a catch of 7,197 t exceeding the TAC of 3,250 t, although the 2015 catch was below the ABC of 12,488 t (in recent years, the TAC for northern rockfish is usually set the much lower than the ABC). The number of tows targeting northern rockfish increased from 60 in 2016 to 290 in 2019, and declined to 232 in 2022. Although these tows comprise a relatively small proportion of the total number of tows in which northern rockfish are caught (Figure 1a), they contribute a large share of the observed catch (Figure 1b). In 2021 and 2022, 33% and 43%, respectively, of the observed northern rockfish catch was obtained in tows targeting northern rockfish, indicating the development of a growing target fishery. The catch of northern rockfish in these tows has generally exceeded 50%, and exceeded 60% in 2013 and 2014 (Figure 1c). Increased targeting of northern rockfish since 2016 has led to increased catches, from 4,536 t in 2016 to 9,948 t in 2023 (through Sept 16), which is the largest on record.

The distribution of the percent northern rockfish in the total catch by haul, for vessels identified as targeting northern rockfish, has ranged between 9% and 99% (Figure 2) from 2019 to 2022. The percent of these target hauls for which the northern rockfish catch exceeded 65% of the total catch ranged between 29% in 2019 to 37% in 2022.

The observer records of catch of northern rockfish in tows targeting northern rockfish was used to compute the catch per unit effort (CPUE) per year, defined as the sum of northern rockfish catch (t) divided by the sum of tow duration (hrs). Northern rockfish fishery CPUE has been relatively stable but shows a slight increase since 2007 (Figure 3a), and years with low catches also had low CPUE values (Figure 3b).

Area-specific exploitation, defined as the yearly catch within a subarea divided by an estimate of the subarea biomass at the beginning of the year, was computed for 2004 to 2023. The subarea biomass was obtained by applying the spatial distributions observed in the survey biomass estimates (after a smoother is applied) to the estimated total biomass from the 2023 recommended assessment model. To provide a reference for evaluating these exploitation rates in the context of our harvest control rule, exploitation rates were compared to the exploitation rate for each year that would result from applying a fishing rate of $F_{40\%}$ to the estimated beginning-year numbers, and this rate is defined as $U_{F40\%}$. The $U_{F40\%}$ rate takes into account maturity, fishing selectivity, size-at-age, and time-varying number at age. Exploitation rates for all subareas are lower than the $U_{F40\%}$ reference, although they increased substantially from 2016 to 2023, particularly in the WAI and CAI (Figure 4).

Temporal variability in northern rockfish catches has occurred in AI subareas. Variability in catches by depth of capture has also been observed, but to a lesser extent (Figure 5). The domestic fishery observer data indicates that the eastern AI accounted for 49% and 63% of the AI harvest in 1990 and 1991, respectively, decreasing to less than 15% of the observed catch from 1997 to 2006 (except 1999 and 2000). In contrast, the proportion of observed catch in the western AI increased from less than 20% from 1991 to 1993 to greater than 40% in most years from 1996-2005, and has decreased to less than 15% from 2011 – 2014 with the closure of the western AI to Atka mackerel fishing in these years. The observed catch of northern rockfish is predominately captured at depths between 100 m and 200 m. The percentage obtained at depths between 200 m and 300 m has been variable, ranging from less than 5% during 2000 – 2007 to between 4% and 14% from 2008 – 2023.

Information on proportion discarded is generally not available for northern rockfish in years where the management categories consist of multi-species complexes. However, because the catches of sharpchin rockfish are generally rare in both the fishery and survey, the discard information available for the "sharpchin/northern" complex can interpreted as northern rockfish discards. This management category was used in 2001 in the EBS, and from 1993-2001 in the AI. Prior to 2003 the discard rates were generally above 80%, with the exception of the mid-1990s when some targeting occurred in the Aleutians Islands (Table 5). Discard rates in the AI have declined from 90% in 2003 to < 10% in most years since 2011. In the eastern Bering Sea, discard rates have declined from 75% in 2003 to < 5% in 2010, and have ranged from 12% to 66% from 2012 to 2022.

Catch by species from BSAI trips targeting rockfish from 2016 to 2023 indicate that the largest non-rockfish species caught are Atka mackerel, walleye pollock (*Gadus chalcogrammus*), Pacific cod (*G. microcephalus*), Kamchatka flounder (*Atheresthes evermanni*), and arrowtooth flounder (*A. stomas*) (Table 6). Northern rockfish are primarily caught in rockfish trips targeting rockfish and Atka mackerel (Table 7). Catch of prohibited species is low in trips targeting rockfish, with the catch of most prohibited species groups averaging less than 5 t or 5000 individuals from 2016-2023 (Table 8). Catch of non-FMP species by in BSAI trips targeting rockfish are largest for giant grenadier (*Albatrossia pectoralis*), sculpins, miscellaneous fish, and unidentified sponge (Table 9).

Non-commercial catch data are shown in Appendix A.

# Data

## Fishery Data

The fishery data is characterized by inconsistent sampling of lengths and ages (Table 10). In some years, such as 1984 and 1987 over 700 fish lengths were obtained but these data samples came from a limited number of hauls. Additionally, the length data from the foreign fishery tended to originate from predominately one location in each year, and was not consistent between years. For example, the 1977 and 1978 fishery length data were collected from Tahoma Bank in the western Aleutians, whereas samples in 1984 were obtained from Seguam Pass and samples in 1987 were obtained from Petral Bank. In the domestic fishery, changes in observer sampling protocol since 1999 have improved the distribution of hauls from which northern rockfish age and length data are collected.

Length measurements and otoliths read from the EBS and AI management areas were combined to create fishery age/size composition matrices, with the length composition within management subareas weighted by the estimated catch numbers from observed tows (Table 11). The selection of fishery length frequency data for the age-structured assessment model was based on the consistency in sampling location and the number of samples collected. Foreign fishery length compositions from 1977 and 1978 were used in the assessment, in part, because of the consistency in their sampling location with other sampling years, the increased numbers of hauls from which they were obtained, and the absence of other length composition data during this portion of the time series. Domestic fishery length compositions from 1996, 1998-1999, 2010, 2012, 2014, 2016, 2018, and 2022 were used in the assessment, and the length and age data from 2000-2009, 2011, 2013, 2015, 2017, and 2019-2021 were used to estimate the age compositions of the fishery catch (Table 12).

The estimated lengths at age by subarea, across all years, is shown in Figure 6, and indicate a cline from small fish in WAI to larger fish in the EAI and SBS areas. In the 2016 and prior assessments, a "global" age-length key, per year, was used to compute the fishery age compositions by ignoring any spatial differences in size at age and using the aggregate sample of otoliths across subareas (i.e., in effect weighting the spatial subareas by the number of read otoliths instead of the fishery catch). Because of the spatial differences in size at age, the fishery age compositions in the 2019 and subsequent assessments were produced by applying area-specific age-length key to the fishery length composition from each area, and weighting the resulting subarea age compositions by the extrapolated catch number by subarea from the North Pacific Groundfish Observer Program. The subareas considered in the assessment are the three

Aleutian Island subareas (western Aleutians (WAI), central Aleutians (CAI), and eastern Aleutians (EAI)), plus the Bering Sea (BS) area. The age compositions produced by the two methods were generally similar to each other (Spencer and Ianelli 2016), which results from randomized sampling of fishery otoliths in which the distribution of read otoliths being relatively similar to the distribution of fishery catch (Figure 7).

The fishery age composition data indicates the relatively strong cohorts in 1984-1985, and 1995. The 2005 year class initially appeared strong through the 2017 sampling year, but in the 2019 and 2020 samples the 2006 year class appears stronger than the 2005 year class (Figure 8, Table 12).

## Survey data

Biomass estimates for other red rockfish were produced from cooperative U.S.-Japan trawl survey from 1979-1985 on the eastern Bering Sea slope, and from 1980-1986 in the Aleutian Islands. U.S trawl surveys on the eastern Bering Sea slope were conducted by the National Marine Fisheries Service (NMFS) in 1988, 1991, and biennially beginning in 2002 (except 2006 and 2014, when the survey was canceled due to lack of funding). NMFS trawl surveys in the Aleutian Islands were conducted in 1991, 1994, 1997, and biennially beginning in 2000. Differences exist between the 1980-1986 cooperative surveys and the U.S. domestic surveys with regard to the vessels and gear design used (Skip Zenger, National Marine Fisheries Service, personal communication). For example, the Japanese nets used in the 1980, 1983, and 1986 cooperative surveys varied between years and included large roller gear, in contrast to the poly-nor'eastern nets used in the current surveys (Ronholt et al 1994), and similar variations in gear between surveys occurred in the cooperative EBS surveys. In previous assessments, these surveys were included in the assessment as to provide some indication of biomass during the 1980s. Given the difficulty of documenting the methodologies for these surveys, and standardizing these surveys with the NMFS surveys, this assessment model is conducted with only the NMFS surveys.

Survey abundance in the western and central Aleutians is generally larger than abundance in the eastern Aleutians and eastern Bering Sea (Table 13), as indicated by a plot of the survey CPUE values by tow (Figure 9). In 2014, the survey abundance in the eastern AI increased sharply to 77,000 t (from an average of 20,000 t from 2006-2012) and has a large coefficient of variation of 0.79, but biomass in this area decreased to 48,000 t in 2016 and 20,000 t in 2018 before increasing to 74,000 t in 2022. Abundance in the western Aleutian Islands also showed a large increase in the 2014 survey (to 346,392 t), but decreased to 123,000 t in the 2022 survey. Areas of particularly high survey abundance are Amchitka Island, Kiska Island, Buldir Island, and Tahoma Bank. The 2022 Aleutian Island survey biomass was 287,000 t, which represents an increase of 25% from the 2018 estimate of 212,472 t. Increases were observed in the WAI, EAI, and southern Bering Sea, but the 2022 biomass estimate in the CAI area decreased from 54,500 t in 2018 to 32,212 t in 2022. The CV for the overall 2022 AI biomass estimate is 0.22. The coefficients of variation (CV) of these biomass estimates by region are generally high, but especially so in the southern Bering Sea portion of the surveyed area (165 W to 170 W), where the CV was less than 0.50 only in the 2000 survey, and was 0.76 for the 2022 survey.

Similar to the fishery data, the size at age data from the AI survey shows a spatial cline with length at age increasing from west to east (Figure 10), and assessments in and prior to 2016 that used a global age-length key, per year, did not account for this pattern. In the 2019 and subsequent assessments, the survey age compositions were produced in a similar manner as the fishery age compositions by applying the area-specific age-length key to the estimated survey length composition from each area, and weighting the resulting subarea survey age compositions by the estimated survey population number. In general, application of the weighted subarea age-length keys produces survey age compositions with relatively fewer young fish and relatively more older fish (Spencer and Ianelli 2016), and this pattern is generally consistent across all survey years. The survey abundance is concentrated in the WAI (Figure 11) which has the smallest size at age; any population-level estimate of size at age and age compositions should reflect that most of the stock is located in an area with smaller size at age. However, the spatial distribution of otoliths has generally not been proportional to the spatial distribution of the population. In years prior to 2016, length-stratified sampling of otoliths occurred in the AI survey, which resulted in relatively similar numbers of otoliths being sampled across subareas irrespective of the subarea abundance. Beginning in 2016, random sampling of otoliths have occurred in the AI survey, which has resulted in the spatial distribution of otoliths samples more closely corresponding to the spatial distribution of abundance (Figure 12). Application of the global age-length key (i.e., weighing the spatial areas by the otolith sample size rather than abundance) gives disproportionate weight to areas with larger size at age, and fish of a given length would be estimated to have a younger age relative to the age composition obtained from applying the subarea age-length keys.

In the 1991-1997 surveys, a large portion of the age composition was less than 15 years old, reflecting relative abundant 1984, 1989, and 1994 cohorts, and more recent survey age composition data indicates a relatively strong 2005 year class (Figure 13, Table 14).

The AFSC biennial EBS slope survey was initiated in 2002 and discontinued with the 2016 survey, with the 2008 and 2014 surveys canceled to due lack of funding. The EBS slope survey biomass estimates of northern rockfish from the 2002-2016 surveys ranged between 3 t (in 2008, 2012, and 2016) and 42 t (2010), with CVs between 0.38 (2002) and 1.0 (in 2008, 2012, and 2016). Given these low levels of biomass, the slope survey results are not used in this assessment.

## Biological Data

The AI survey provides data on age and length composition of the population, growth rates, and length-weight relationships. The number of otoliths read and lengths measured are shown in Table 15, along with the number of hauls producing these data. The number of otoliths read by area is shown in Table 16. The surveys collect reasonable sample sizes of lengths and otoliths from throughout the survey area. The survey otoliths are read with the break and burn method, and are thus considered unbiased (Chilton and Beamish 1982).

As indicated above, the expected length at age differs between the four AI survey subareas (Figure 10). Variability occurs between years but without any apparent direction trend as indicated by the $L_{inf}$ and $K$ parameters (Figure 14). Additionally, the weight-at-length relationship ($W = aL^b$) also shows spatial differences, with generally larger values of the exponential parameter $b$ in the WAI and CAI (Figure 15). The estimated survey weight at age curves by AI subarea are shown in Figure 16. A similar pattern across areas is seen in the subareas weights at age in the fishery; additionally, the fishery weights at age are generally larger than those from the AI survey.

In assessments in and prior to 2016, “global” estimates of length and weight at age were computed by ignoring any spatial differences and using the aggregate sample of otoliths across subareas to construct a single age-length key for each year (i.e., in effect weighting the spatial distribution of read otoliths by their sample size instead of the population size). In the 2019 and subsequent assessments, the size at age for the population was obtained from the 1991-2022 AI survey data as an average of each of the 4 subarea weight at age curves shown in Figure 16 (weighted by a smoothed estimate of survey abundance). Years prior to 1991 were set to the weight at values from 1991, whereas the values for 2022 to present were set to the 2022 values. A similar procedure was used for the fishery weights at age from 1990 - 2022, with the subarea curves weighted by the extrapolated catch number by subarea from the North Pacific Groundfish Observer Program. Fishery weights at age prior to 1990 were set to an average of the 1990-1992 values, whereas fishery weights at age in 2023 were set to the 2022 values. An average of the 2016-2022 survey weight at age, and an average of the 2017-2021 fishery weight at age, is shown in Table 17.

Fishery length data are used in the model, and a conversion matrix was created to convert modeled number at ages to modeled number at length bin, and consists of the proportion of each age that is expected in each length bin. The expected size at age for the conversion matrix is an average of the yearly fishery size at age curves from 1990-2020 described above. The conversion matrix was created by fitting a power relationship to the observed standard deviation in length at each age (obtained from the aged fish in the fishery from 1998-2021), and the predicted relationship was used to produce variation around the predicted size at age from the von Bertalanffy relationship. The resulting CVs of length at age of the transition matrix decrease from 0.11 at age 3 to 0.08 at age 40.

The following table summarizes the data available for the BSAI northern rockfish model:

| Component | BSAI |
|---|---|
| Fishery catch | 1977-2023 |
| Fishery age composition | 2000-2009, 2011, 2013, 2015, 2017, 2019-2021 |
| Fishery size composition | 1977-1978, 1996, 1998-1999, 2010, 2012, 2014, 2016, 2018, 2022 |
| Survey age composition | 1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, 2016, 2018, 2022 |
| Survey biomass estimates | 1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, 2016, 2018, 2022 |

# Analytic Approach

## Model structure

An age-structured population model, implemented in the software program AD Model Builder, was used to obtain estimates of recruitment, numbers at age, and catch at age. The model is identical to the accepted model for the 2021 assessment, and uses the same ADMB modeling framework since the initial age-structured model for BSAI northern rockfish in 2003. Francis weighting is used for the composition data, and prior distributions were used for survey catchability, the natural mortality rate *M*, and the survey selectivity curve. The definitions of model parameters and quantities is shown in Table 18, and equations for population dynamics, estimated quantities, and likelihood components are shown in Tables 19-20.

The root mean squared error (RMSE) was used to evaluate the relative size of residuals within data types:

$$RMSE = \sqrt{\frac{\sum_{n} (\ln(y) - \ln(\hat{y}))^2}{n}}$$

*Description of Alternative Models*

The model used in this assessment is the accepted model from the 2021 assessment, and alternative models are not considered

*Parameters Estimated Outside the Assessment Model*

The parameters estimated independently include the age error matrix, the age-length conversion matrix, and the individual fishery and population (i.e., AI survey) weights at age. The derivation of the age-length conversion matrix and the weight at age vector are described above.

The ageing error matrix was updated using the Punt et al. (2008) methodology based on maximum likelihood, and requires a set of multiple age readers for each fish.. The mean and standard deviation of the read ages for each reader was estimated based on the likelihood of observing the read age for each fish given the true age. The true ages are unobserved, and maximum likelihood estimates are obtained by integrating across all possible values for the true age. It was assumed that the readers had equal variation in the read ages and were unbiased. Additionally, the coefficient of variation of the read ages was modeled as constant with age (i.e., the standard deviation of increases linearly with age).

This estimation procedure differs from that used to generate the ageing error matrix in the 2021 model, which is not based on fitting data on individual fish but rather fits the percent agreement for each age (and weights each age equally regardless of differences in sample size). Additionally, the data used for the ageing error matrix in the 2021 model was sampled in the Gulf of Alaska from the Gulf of Alaska from 1984-1993, whereas the Punt et al. (2008) methodology was applied to 3213 double readings of northern rockfish from the BSAI sampled during 1980 – 2022. The updated ageing error shows higher CVs in read ages than was estimated for the 2021 model, with the CV from the Punt et al. (2008) methodology estimated at 0.077 for all ages, whereas the CV used in the 2021 assessment was estimated at 0.029 (for age 40) (Figure 17). For older fish, the difference in the ageing error matrices results in approximately 20% less fish being read as the true age with the new matrix, and slight increases in the proportion being assigned ages more than 2-5 years different than the true age (Figure 18).

*Parameters Estimated Inside the Assessment Model*

Parameters estimated inside the assessment model include the mean and annual deviations for recruitment and fishing mortality, survey catchability, natural mortality, and the parameters associated with the curves for fishery selectivity, survey selectivity, and maturity-at-age.

Prior distributions were used for the survey catchability, the natural mortality rate *M*, and the survey selectivity curve. A lognormal distribution was used for the natural mortality rate *M*, with the mean set to 0.06 (the value used in previous assessments, based upon expected relationships between *M* and longevity identified in Then et al. (2015), with the CV set to 0.15. The standard deviation of log recruits, $\sigma_r$, was fixed at 0.75. Similarly, the prior distribution for survey catchability followed a lognormal distribution with a mean of 1.0 and a coefficient of variation (CV) of 0.001, essentially fixing survey catchability at 1.0.

The "observed" catch for 2023 is obtained by estimating the Oct-Dec catch (based on the remaining ABC available after October, and the average proportion in recent years of the remaining ABC caught from Oct-Dec) and adding this to the observed catch through October.

A maturity ogive was fit in the assessment model to samples collected in 2010 (*n*=322; TenBrink and Spencer 2013) and in 2004 by fishery observers (*n*=256). Parameters of the logistic equation were estimated by maximizing the binomial likelihood within the assessment model. The number of fish sampled and number of mature fish by age for each collection were the input data, thus weighting the two collection by sample size. Due to the low number of young fish, high weights were applied to age 3 and 4 fish in order to preclude the logistic equation from predicting a high proportion of mature fish at age 0. The estimated age at 50% maturity is 8.2 years.

The number of estimated parameters is shown below :

| Parameter type | Number |
|---|---|
| 1) fishing mortality mean | 1 |
| 2) fishing mortality deviations | 47 |
| 3) recruitment mean | 1 |
| 4) recruitment deviations | 44 |
| 5) Initial recruitment | 1 |
| 6) first year recruitment deviations | 37 |
| 7) biomass survey catchability | 1 |
| 8) natural mortality rate | 1 |
| 9) survey selectivity parameters | 2 |
| 10) fishery selectivity parameters | 2 |
| 11) maturity parameters | 2 |
| Total number of parameters | 139 |

# Results

## Model Evaluation

The assessment model is unchanged from the accepted 2021 model, and there are no alternative models to evaluate.

The negative log-likelihoods of the data components and prior distributions, and the root mean squared errors, for the 2021 assessment and the 2023 assessment are shown in Table 21. The general pattern in these values are similar to each other between the two assessment years. The fishery and survey age composition likelihoods contribute most of the negative log-likelihood, with larger values in the 2023 assessment due to the increased amount of data. The root mean squared error for recruitment (reflecting the interannual variation) was larger in the 2023 assessment, which results from the updated ageing error matrix.

A series of bridging models were conducted to evaluate the effect of each updated data component on the model output (Figure 19). The 2022 survey biomass estimated had the largest effect of any single model change, and increased the estimated total biomass for 2023 by 6% over the model with only the catch data updated. The combined effect of the updated composition data raised the estimated total biomass for 2023 by an additional 4%. Changes in size at age in recent years (i.e., more of the survey abundance in the southern Bering Sea) further increased the post-2018 biomass estimates. In contrast, the updated ageing error matrix had little effect on estimated total biomass. The data weights were very similar between the 2021 and 2023 assessments (Figure 20).

A list of parameter estimates and their standard deviations from Model 21 from the 2023 assessment is shown in Table 22.

## Time series results

In this assessment, spawning biomass is defined as the biomass estimate of mature females age 3 and older. Total biomass is defined as the biomass estimate of northern rockfish age 3 and older.  Recruitment is defined as the number of age 3 northern rockfish.

The estimated values for total biomass, spawning biomass, and recruitment, and their CVs (from the Hessian approximation) are shown in Table 23, and the estimated numbers at age are shown in Table 24.

## Biomass trends

The estimated survey biomass shows an increasing trend, starting at 91,159 t in 1977 and increasing to a peak of 256,819 t in 2014, and declining to 236,604 t in 2023 (Figure 21). The estimated total biomass shows a similar trend, increasing to a peak value of 343,230 t in 2014, and the estimated spawning biomass increases from 55,180 in 1977 to its highest value of 151,130 in 2015 (Table 23, Figure 22).

## Age/size compositions

The model fits to the fishery age and size compositions are shown in Figures 23-24, and the model fit to the survey age composition data is shown in Figure 25. The model fit the fishery and survey age composition data reasonably well (notwithstanding years with low sample sizes). The number of hauls in which otoliths or length measurements has increased in recent years (in part due to the random sampling of otoliths initiated in the AI survey beginning in 2016), which results in the higher weights placed on the recent composition data relative to the earlier years. The plus group in the fishery length composition data (38 cm+) and the fishery age plus group (40+ years) are often overestimated whereas the survey age plus group is often underestimated, reflecting a trade-off in the model.

## Fishing and survey selectivity

The estimated survey selectivity curve had an age at 50% selection of 11.3, similar to the estimate of 11.1 in the 2021 assessment. The selectivity slope parameter was 0.28, identical to the value in the 2021 assessment. The fishery selectivity had an age of 50% selection of 9.2, similar to the value of 9.1 obtained from the 2021 assessment (Figure 26).

## Fishing mortality

The estimates of fully selected instantaneous fishing mortality rates are shown in Figure 27. A relatively high rate in 1977 is estimated to account for the relatively high catch in this year, followed by very low levels of fishing mortality during the 1980s when catch was small. Fishing mortality rates began to increase during the early 1990s, and declined from the late 1990s to 2014. Fishing mortality rates have increased since 2014, and the 2023 estimate of 0.034 is the largest $F$ in the estimated time series beginning in 1977. A plot of fishing mortality rates and spawning stock biomass in reference to the ABC and OFL harvest control rules indicates that the stock is currently below $F_{35\%}$ and above $B_{40\%}$ (Figure 28).

## Recruitment

Recruitment strengths by year class are shown in Figure 29. Relatively strong year classes are observed in 1984-1985, 1989, 1993, 1995-1998, and 2005, reflecting several of the strong year classes observed in the age composition input data (Figures 23 and 25). Most of these estimated strong year classes are larger than their estimates in the 2021 assessment, ands years adjacent to the strong year classes are often smaller than estimated in the 2021 assessment (for example, the 1985, 1989, and 2005 year classes). This reflects the influence of the updated aging error matrix; the greater uncertainty in the observed ages allows stronger recruitments which will be distributed to a greater degree to adjacent observed ages. The scatterplot of recruitment against spawning stock biomass is shown in Figure 30, indicating substantial variability in the pattern between recruitment and spawning stock size.

## Retrospective analysis

A retrospective analysis was conducted to evaluate the effect of recent data on estimated spawning stock biomass. For the current assessment model, a series of model “peels” were conducted in which the end year of the model was varied from 2023 to 2013, and this was accomplished by sequentially dropping age and length composition data, survey biomass estimates, and catch from the input data files.

The plot of retrospective estimates of spawning biomass is shown in Figure 31. The retrospective estimates show distinct groups that reflect years when survey data are included in the assessment. For example, all the retrospective runs ending in 2018 to 2021 are very similar to each other. The retrospective runs for 2022 and 2023 are also consistent with each other but show larger biomass than the 2018 – 2021 group due to the large 2022 survey biomass estimate. The 2022 and 2018 survey biomass estimates are influential, and exclusion of these data result in a lower group of retrospective SSB estimates for the 2014-2016 peels. Mohn's rho can be used to evaluate the severity of any retrospective pattern, and compares an estimated quantity (in this case, spawning stock biomass) in the terminal year of each retrospective model run with the estimated quantity in the same year of the model using the full data set . The absence of any retrospective pattern would result in a Mohn's rho of 0, and would result from either identical estimates in the model runs, or from positive deviations from the reference model being offset by negative deviations. The Mohn's rho for these retrospective runs was -0.16, similar to the value of -0.18 obtained in the in the 2021 assessment.

# Harvest recommendations

## Amendment 56 reference points

The reference fishing mortality rate for northern rockfish is determined by the amount of reliable population information available (Amendment 56 of the Fishery Management Plan for the groundfish fishery of the Bering Sea/Aleutian Islands). Estimates of $F_{40\%}$, $F_{35\%}$, and $SPR_{40\%}$ were obtained from a spawner-per-recruit analysis. Assuming that the average recruitment from the 1977-2017 year classes estimated in this assessment represents a reliable estimate of equilibrium recruitment, then an estimate of $B_{40\%}$ is calculated as the product of $SPR_{0.40}$ * equilibrium recruits, and this quantity is 74,907 t. The year 2024 spawning stock biomass is estimated as 128,229 t.

## Specification of OFL and maximum permissible ABC

Since reliable estimates of the 2022 spawning biomass ($B$), $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist and $B$>$B_{40\%}$ (128,229 t > 74,907 t), northern rockfish reference fishing mortality is defined in Tier 3a. For this tier, the maximum permissible (MaxPerm) $F_{ABC}$ is defined as $F_{40\%}$ and $F_{OFL}$ is defined as $F_{35\%}$. The values of $F_{40\%}$ and $F_{35\%}$ are 0.070 and 0.086, respectively.

**The ABC associated with the $F_{40\%}$ level of 0.070 is 19,274 t**.

The estimated catch level for year 2024 associated with the overfishing level of $F_{35\%}$ = 0.086 is 23,556 t. A summary of these values is below.

| | | |
|---|---|---|
| **2024 SSB estimate (B)** | **=** | **128,229 t** |
| $B_{40\%}$ | = | 74,907 t |
| MaxPerm $F_{ABC}$ | = | 0.070 |
| $F_{ABC} = F_{40\%}$ | = | 0.070 |
| $F_{OFL} = F_{35\%}$ | = | 0.086 |
| ABC | = | 19,274 t |
| OFL | = | 23,556 t |

## Projections

A standard set of projections is required for each stock managed under Tiers 1, 2, or 3 of Amendment 56. This set of projections encompasses seven harvest scenarios designed to satisfy the requirements of Amendment 56, the National Environmental Policy Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

For each scenario, the projections begin with the vector of 2023 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2024 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2023. In each subsequent year, the fishing mortality rate is prescribed on the basis of the spawning biomass in that year and the respective harvest scenario. In each year, recruitment is drawn from an inverse Gaussian distribution whose parameters consist of maximum likelihood estimates determined from recruitments estimated in the assessment. Spawning biomass is computed in each year based on the time of peak spawning and the maturity and weight at age schedules described in the assessment. Total catch is assumed to equal the catch associated with the respective harvest scenario in all years. This projection scheme is run 1000 times to obtain distributions of possible future stock sizes, fishing mortality rates, and catches.

Five of the seven standard scenarios will be used in an Environmental Assessment prepared in conjunction with the final SAFE. These five scenarios, which are designed to provide a range of harvest alternatives that are likely to bracket the final TAC for 2024, are as follows ("*max* $F_{ABC}$" refers to the maximum permissible value of $F_{ABC}$ under Amendment 56):

> *Scenario 1*: In all future years, $F$ is set equal to *max* $F_{ABC}$. (Rationale: Historically, TAC has been constrained by ABC, so this scenario provides a likely upper limit on future TACs.)
>
> *Scenario 2*: In all future years, $F$ is set equal to a constant fraction of *max* $F_{ABC}$. (Rationale: When $F_{ABC}$ is set at a value below *max* $F_{ABC}$, it is often set at the value recommended in the stock assessment. For this assessment, the fraction used was 1.)
>
> *Scenario 3*: In all future years, $F$ is set equal to $F_{75\%}$. (Rationale: This scenario provides a likely lower bound on $F_{ABC}$ that still allows future harvest rates to be adjusted downward when stocks fall below reference levels.)
>
> *Scenario 4*: In all future years, $F$ is set equal to the 2018-2022 average $F$. (Rationale: For some stocks, TAC can be well below ABC, and recent average $F$ may provide a better indicator of $F_{TAC}$ than $F_{ABC}$.)
>
> *Scenario 5*: In all future years, $F$ is set equal to zero. (Rationale: In extreme cases, TAC may be set at a level close to zero.)

Two other scenarios are needed to satisfy the MSFCMA's requirement to determine whether a stock is currently in an overfished condition or is approaching an overfished condition. These two scenarios are as follows (for Tier 3 stocks, the MSY level is defined as $B_{35\%}$):

> *Scenario 6*: In all future years, $F$ is set equal to $F_{OFL}$. (Rationale: This scenario determines whether a stock is overfished. If the stock is expected to be above 1) above its MSY level in 2023 or 2) above ½ of its MSY level in 2023 and above its MSY level in 2033 under this scenario, then the stock is not overfished.)
>
> *Scenario 7*: In 2024 and 2025, $F$ is set equal to *max* $F_{ABC}$, and in all subsequent years $F$ is set equal to $F_{OFL}$. (Rationale: This scenario determines whether a stock is approaching an overfished condition. If the stock is expected to be above its MSY level in 2035 under this scenario, then the stock is not approaching an overfished condition.)

The recommended $F_{ABC}$ and the maximum $F_{ABC}$ are equivalent in this assessment (scenarios one and two), and projections of the mean harvest, spawning stock biomass, and fishing mortality rate for the remaining five scenarios are shown in Table 25.

## Risk Table and ABC recommendation

*Overview*

The risk table categories have been altered for 2023, with the category of "substantial concern" being eliminated. We used the following risk table template:

| | *Assessment-related considerations* | *Population dynamics considerations* | *Environmental/ecosystem considerations* | *Fishery Performance* |
|---|---|---|---|---|
| Level 1: Normal | Typical to moderately increased uncertainty/minor unresolved issues in assessment. | Stock trends are typical for the stock; recent recruitment is within normal range. | No apparent environmental/ecosystem concerns | No apparent fishery/resource-use performance and/or behavior concerns |
| Level 2: Major Concern | Major problems with the stock assessment; very poor fits to data; high level of uncertainty; strong retrospective bias. | Stock trends are highly unusual; very rapid changes in stock abundance, or highly atypical recruitment patterns. | Multiple indicators showing consistent adverse signals a) across the same trophic level as the stock, and/or b) up or down trophic levels (i.e., predators and prey of the stock) | Multiple indicators showing consistent adverse signals a) across different sectors, and/or b) different gear types |
| Level 3: Extreme concern | Severe problems with the stock assessment; severe retrospective bias. Assessment considered unreliable. | Stock trends are unprecedented; More rapid changes in stock abundance than have ever been seen previously, or a very long stretch of poor recruitment compared to previous patterns. | Extreme anomalies in multiple ecosystem indicators that are highly likely to impact the stock; Potential for cascading effects on other ecosystem components | Extreme anomalies in multiple performance indicators that are highly likely to impact the stock |

The table is applied by evaluating the severity of four types of considerations that could be used to support a scientific recommendation to reduce the ABC from the maximum permissible. These considerations are stock assessment considerations, population dynamics considerations, environmental/ecosystem considerations, and fishery performance. Examples of the types of concerns that might be relevant include the following:

1. Assessment considerations—data-inputs: biased ages, skipped surveys, lack of fishery-independent trend data; model fits: poor fits to fits to fishery or survey data, inability to simultaneously fit multiple data inputs; model performance: poor model convergence, multiple minima in the likelihood surface, parameters hitting bounds; estimation uncertainty: poorly-estimated but influential year classes; retrospective bias in biomass estimates.

2. Population dynamics considerations—decreasing biomass trend, poor recent recruitment, inability of the stock to rebuild, abrupt increase or decrease in stock abundance.

3. Environmental/ecosystem considerations—adverse trends in environmental/ecosystem indicators, ecosystem model results, decreases in ecosystem productivity, decreases in prey abundance or availability, increases or increases in predator abundance or productivity.

4. Fishery performance—fishery CPUE is showing a contrasting pattern from the stock biomass trend, unusual spatial pattern of fishing, changes in the percent of TAC taken, changes in the duration of fishery openings.

*Assessment considerations*

Several major aspects of the biology of the northern rockfish, and our ability to infer abundance from the AI trawl survey are uncertain, including the natural mortality rate, survey catchability, and survey selectivity. Survey catchability and selectivity are highly constrained by prior distributions, which underestimates the level of uncertainty in the assessment and impedes our ability to estimate the scale of abundance. In addition, the retrospective bias is the assessment is still relatively high and can be attributed to a large biomass estimate from the 2014 AI trawl survey, and differences in the estimated survey selectivity as additional age composition data are included. The Mohn's rho of -0.16 is similar to the Mohn's rho in the 2021 assessment (-0.18). More generally, the retrospective bias indicates that the increase in biomass observed in the data is not consistent with the modeled estimates of survey catchability and mortality. Finally, the 2020 survey was cancelled due to Covid-19, and skipped surveys were identified as one criteria in evaluating assessment considerations for the risk table. We rank the assessment considerations as a 2 (*Major concern with assessment uncertainty, and strong retrospective bias*).

*Population dynamics considerations*

The trend in survey biomass abundance based on the estimates from the 1994 to 2014 show a rapid increase, resulting from low biomass in the 1994 and 1997 surveys and a high biomass in the 2014 survey. However, reduced biomass estimates from the 2016, 2018, and 2022 surveys are more consistent with the remainder of the time series than the 2014 estimate, and have resulted in a more stable trend in biomass over time. The recruitment of some recent year classes, such as 2005, are estimated to be relatively high.

Northern rockfish show genetic structure within the Aleutian Islands, with the lifetime dispersal distances estimated as not exceeding 250 km (Gharrett et al. 2012). Spatial management of the harvest does not occur within the BSAI, so a population dynamics consideration is that the spatial management of the stock is not consistent with the spatial structure of the stock. This could lead to disproportionate harvest rates within BSAI subareas, with depletion and loss of fishery yield. This risk has not been realized yet as exploitation rates are currently relatively low, and this risk would be lessened if the catches only occurred as bycatch in other target fisheries. However, the recent increased catches and relatively high proportion of catch taken in targeted tows, when combined with the lack of spatial harvest management, increases the risk of disproportionately high subarea harvest rates in the future, which could result in unusual spatial patterns in stock trends and a potentially limited capacity to rebuild quickly locally depleted areas. Overall, we rank the assessment considerations as a 2 (*Major concern*)

*Environmental/Ecosystem considerations*

Northern rockfish are mostly found in the top 200 m, at a mean depth of ~165 m in the Aleutian Islands and within temperatures ranging from 2 to 7.7 °C (mean 4.4 °C). In general, higher ambient temperatures incur bioenergetic costs for ectothermic fish such that, all else being equal, consumption must increase to maintain fish condition. Annual mean sea surface temperature in the North Pacific (including all Alaskan waters) had a regime shift to warmer temperatures in 2013-2014 (Xioa and Ren 2023), which is consistent with an increasing trend of bottom temperature observed in the AI trawl survey since 2014. The longline survey data also show a general increase in the eastern AI temperatures throughout the water column beginning in 2014 (Siwicke, 2023). The Extended Reconstructed Sea Surface Temperature (ERSST) dataset (Thoman, 2023) and satellite data (Lemagie and Callahan, 2023) show 2023 to be one of the warmest winters on record. Based on sea surface temperatures (SST), the eastern Aleutian Islands experiencing an increase in extension and intensity of the marine heat wave (MHW) whereas the western Aleutians are currently experiencing a moderate MHW, with one of the warmest fall SST. In 2022, the occupied mean-weighted temperature for northern rockfish was lower than the previous two surveys, although the overall trend over the time series is toward occupying warmer temperatures

Thus, the persistent higher temperatures may be considered a negative indicator for northern rockfish, and combined with higher competition and high biomass of POP, may have jointly contributed to the below average northern rockfish body condition since 2012. Despite remaining below the long-term average, body condition in 2022 did improve compared to that observed in 2018 in all areas except for the western Aleutians. The below-average condition indicates suboptimal foraging conditions are still widespread throughout the Aleutians.

Given that the majority of the biomass of northern rockfish is in the western AI ecoregion, we reviewed indicators from this ecoregion. Reproductive success of planktivorous birds can serve as indirect indicators of prey abundance for northern rockfish, particularly those <30 cm that primarily eat zooplankton. Within the western Aleutians, POP and northern rockfish dominate the pelagic forager guild over Atka mackerel and pollock which were the most abundant in the early 1990s. At Buldir Island (western Aleutian Islands), conditions have changed from above-average reproductive success for all seabirds, to average- to below-average reproductive success for those seabirds with mixed or strictly planktivorous diets (squid, euphausiids, amphipods) and reproductive failure of red kittiwakes (mixed diet). This indicates there is sufficient zooplankton prey but perhaps not as varied and abundant as in the past couple years to support reproduction in the western AI. Piscivorous and cephalopod-eating tufted puffins had above-average reproductive success, indicating that forage fish to support chick-rearing was available this year. For 2023, seabird success suggests potentially lower availability of prey than last year, which overlaps with prey of northern rockfish larger than 20 cm (zooplankton and squid, amphipods).

Based on the availability of prey, temperature trends, and fish condition in 2022 compared to 2018 and the population trend, we consider the level of concern to be 1 (no apparent environmental/ ecosystem concern).

*Fishery performance*

The growth of the northern rockfish stock since the mid-2000s has led to the development of a target fishery, initially during 2011-2014 when Atka mackerel fishing in the WAI was closed, and more recently since 2016. The CPUE and the number of hauls in which northern rockfish are identified as the target species (based on species composition) have increased from 2021 to 2022. Additionally, the proportion of the harvest obtained in these northern rockfish targeted tows remains generally high, and the catch as a percentage of the ABC has increased since 2014. This indicates that the fishing fleet has not encountered reduced performance in their ability to target this stock. Inferring conditions of the stock based on fishery indicators is difficult due to the evident change in targeting behavior over time. We rank the fishery performance as a 1 (*No apparent fishery/resource-use performance and/or behavior concerns*).

*Summary and ABC recommendation*

The assessment–related concerns relate to the retrospective pattern in the assessment, the use of strong priors for some key model parameters that cannot be reliably estimated (in effect understating the level of uncertainty in the assessment), and cancelation of the 2020 survey. A population dynamics concern is that the spatial management of the stock is not consistent with the genetic spatial structure, which could lead to subarea depletion and loss of fishery yield, particularly as the target fishery for northern rockfish is developing; however, this risk has not been realized yet.

The concerns identified above are not addressed in the assessment and Tier status for this stock. Issues such as the retrospective pattern and the use of strong prior distributions affect the results of the assessment, but are not mitigated or otherwise addressed within the assessment. These factors are also not addressed by our current Tier system. Additionally, the mismatch between the genetic spatial structure and the spatial management of the stock is also not addressed within the assessment or the Tier system, as this issue extends beyond the assessment itself. Simply lowering the ABC to a level below the max ABC would not be an effective remedy for a misspecification in the spatial management of the stock.

These assessment-related risk factors are concerning and motivate further continued monitoring of the stock. It is difficult to quantitatively assess the potential for the estimated maximum ABC to exceed the true OFL to due to these risk factors. We recommend the maximum permissible ABC 19,274 t for 2024.

## Status Determination

In addition to the seven standard harvest scenarios, Amendments 48/48 to the BSAI and GOA Groundfish Fishery Management Plans require projections of the likely OFL two years into the future. While Scenario 6 gives the best estimate of OFL for 2024, it does not provide the best estimate of OFL for 2025, because the mean 2024 catch under Scenario 6 is predicated on the 2024 catch being equal to the 2024 OFL, whereas the actual 2024 catch will likely be less than the 2024 OFL. Catches for 2024 and 2025 were obtained by setting the $F$ rate for these years to the average of the estimated $F$ rates for 2022 and 2023.

The executive summary contains the appropriate one- and two-year ahead projections for both ABC and OFL.

Under the MSFCMA, the Secretary of Commerce is required to report on the status of each U.S. fishery with respect to overfishing. This report involves the answers to three questions: 1) Is the stock being subjected to overfishing? 2) Is the stock currently overfished? 3) Is the stock approaching an overfished condition?

*Is the stock being subjected to overfishing?* The official BSAI catch estimate for the most recent complete year (2022) is 7,898 t. This is less than the 2022 BSAI OFL of 23,420 t. Therefore, the stock is not being subjected to overfishing.

Harvest Scenarios #6 and #7 are intended to permit determination of the status of a stock with respect to its minimum stock size threshold (MSST). Any stock that is below its MSST is defined to be *overfished*. Any stock that is expected to fall below its MSST in the next two years is defined to be *approaching* an overfished condition. Harvest Scenarios #6 and #7 are used in these determinations as follows:

*Is the stock currently overfished?* This depends on the stock's estimated spawning biomass in 2023:

a. If spawning biomass for 2023 is estimated to be below ½ $B_{35\%}$, the stock is below its MSST.

b. If spawning biomass for 2023 is estimated to be above $B_{35\%}$ the stock is above its MSST.

c. If spawning biomass for 2023 is estimated to be above ½ $B_{35\%}$ but below $B_{35\%}$, the stock's status relative to MSST is determined by referring to harvest Scenario #6 (Table 25). If the mean spawning biomass for 2033 is below $B_{35\%}$, the stock is below its MSST. Otherwise, the stock is above its MSST.

*Is the stock approaching an overfished condition?* This is determined by referring to harvest Scenario #7:

a. If the mean spawning biomass for 2025 is below 1/2 $B_{35\%}$, the stock is approaching an overfished condition.

b. If the mean spawning biomass for 2025 is above $B_{35\%}$, the stock is not approaching an overfished condition.

c. If the mean spawning biomass for 2025 is above 1/2 $B_{35\%}$ but below $B_{35\%}$, the determination depends on the mean spawning biomass for 2035. If the mean spawning biomass for 2035 is below $B_{35\%}$, the stock is approaching an overfished condition. Otherwise, the stock is not approaching an overfished condition.

The results of these two scenarios indicate that the BSAI northern rockfish stock is neither overfished nor approaching an overfished condition. With regard to whether the stock is currently overfished, the estimated 2023 stock size is 2.0 times its $B_{35\%}$. value of 65,544 t. With regard to whether BSAI northern rockfish is likely to be overfished in the future, the expected stock size in 2025 of Scenario 7 is 1.8 times the $B_{35\%}$ value.

Based on the recommended model, the $F$ that would have produced a catch for 2022 equal to the 2022 OFL is 0.079.

# Ecosystem Considerations

## Ecosystem Effects on the stock

1) Prey availability/abundance trends

Northern rockfish feed primarily upon zooplankton, including calanoid copepods, euphausids, and chaetonaths. From a sample of 118 Aleutian Island specimens collected in 1994, calanoid copepods, euphausids, and chaetognaths contributed 84% of the total diet by weight. Small northern rockfish (<30 cm FL) consumed a higher proportion of calanoid copepods than larger northern rockfish, whereas euphausids were consumed primarily by fish larger than 25 cm. Myctophids and cephalopods were consumed mainly by the largest size group, contributing 11% and 16%, respectively, of the diet for fish > 35 cm. The availability and abundance trends of these prey species are unknown.

2) Predator population trends

Northern rockfish are not commonly observed in field samples of stomach contents. Pacific ocean perch, a rockfish with similar life-history characteristics as northern rockfish, has been found in the stomachs of Pacific halibut and sablefish (Major and Shippen 1970), and it is likely that these species also prey upon northern rockfish as well. The population trends of these predators can be found in separate chapters within this SAFE report.

3) Changes in habitat quality

Little information exists on the habitat use of northern rockfish. Carlson and Straty (1981) and Krieger (1993) used submersibles to observe that other species of rockfish appear to use rugged, shallower habitats during their juvenile stage and move deeper with age. Although these studies did not specifically observe northern rockfish, it is reasonable to suspect a similar ontogenetic shift in habitat. Length frequencies of the Aleutian Islands survey data indicate that small northern rockfish (< 25 cm) are generally found at depths less than 100 m. The mean depths of northern rockfish from recent AI trawl surveys have ranged between 100 and 150 m. There has been little information identifying how rockfish habitat quality has changed over time.

### Fishery Effects on the ecosystem

Northern rockfish has historically been a bycatch fishery, with the catches largely occurring in the BSAI Atka mackerel and Pacific ocean perch fisheries. The ecosystem effects of these fisheries can be found in their respective SAFE documents. Targeted fishing for northern rockfish has been increasing in recent years.

Harvesting of northern rockfish is not likely to diminish the amount of northern rockfish available as prey due to the low fishery selectivity for fish less than 20 cm. Although the recent fishing mortality rates have been relatively light, averaging 0.02 over the last five years, it is not known what the effect of harvesting is on the size structure of the population or the maturity at age.

## Data Gaps and Research Priorities

Little information is known regarding most aspects of the biology of northern rockfish, particularly in the Aleutian Islands. Recent genetic data suggests that the spatial movement of northern rockfish, per generation, may be much smaller than the BSAI management area. More generally, little is known regarding the reproductive biology, distribution, duration, and habitat requirements of various life-history stages. Given the relatively unusual reproductive biology of rockfish (i.e., maternal effects, and skipped spawning) and its importance in establishing management reference points, data on reproductive capacity should be collected on a periodic basis.

Further research on the functional form of survey selectivity should be investigated, with the aim of achieving estimates of survey selectivity and /or to inform use of a prior distribution. Previous assessments have considered alternative fishery selectivity formulations (i.e., dome-shaped and/or time-varying), and these formulations could be explored for the survey as well. Studies on the distribution of fish in trawlable and untrawlable grounds may help refine our prior distribution of survey catchability.

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Table 1. Total allowable catch (TAC), acceptable biological catch (ABC), and catch of the species groups used to manage northern rockfish from 1977 to 2000 in the Aleutian Islands and the eastern Bering Sea. The "other red rockfish" group includes, shortraker rockfish, rougheye rockfish, northern rockfish, and sharpchin rockfish. The "POP complex" includes the other red rockfish species plus POP.

| | Aleutian Islands | | | | | Eastern Bering Sea | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Management Group | OFL (t) | ABC (t) | TAC (t) | Catch (t) | Management Group | OFL (t) | ABC (t) | TAC (t) | Catch (t) |
| 1977 | Other species | | | | 3264 | Other species | | | | 5 |
| 1978 | Other species | | | | 3655 | Other species | | | | 32 |
| 1979 | POP complex | | | | 601 | POP complex | | | | 46 |
| 1980 | POP complex | | | | 549 | POP complex | | | | 89 |
| 1981 | POP complex | | | | 111 | POP complex | | | | 35 |
| 1982 | POP complex | | | | 177 | POP complex | | | | 71 |
| 1983 | POP complex | | | | 47 | POP complex | | | | 42 |
| 1984 | POP complex | | | | 196 | POP complex | | | | 32 |
| 1985 | POP complex | | | | 189 | POP complex | | | | 6 |
| 1986 | Other rockfish | n/a | UN | 5800 | 208 | Other rockfish | n/a | UN | 825 | 61 |
| 1987 | Other rockfish | n/a | UN | 1430 | 308 | Other rockfish | n/a | UN | 450 | 77 |
| 1988 | Other rockfish | n/a | 1100 | 1100 | 493 | Other rockfish | n/a | 400 | 400 | 40 |
| 1989 | POP complex | n/a | 16600 | 6000 | 306 | POP complex | n/a | 6000 | 5000 | 78 |
| 1990 | POP complex | n/a | 16600 | 6000 | 1235 | POP complex | n/a | 6300 | 6300 | 247 |
| 1991 | Other red rockfish | 0 | 4685 | 4685 | 233 | Other red rockfish | 0 | 1670 | 1670 | 626 |
| 1992 | Sharpchin/northern | 5670 | 5670 | 5670 | 1548 | Other red rockfish | 1400 | 1400 | 1400 | 309 |
| 1993 | Sharpchin/northern | 5670 | 5670 | 5100 | 4530 | Other red rockfish | 1400 | 1400 | 1200 | 859 |
| 1994 | Sharpchin/northern | 5670 | 5670 | 5670 | 4666 | Other red rockfish | 1400 | 1400 | 1400 | 61 |
| 1995 | Sharpchin/northern | 5670 | 5670 | 5103 | 3858 | Other red rockfish | 1400 | 1400 | 1260 | 266 |
| 1996 | Sharpchin/northern | 5810 | 5810 | 5229 | 6637 | Other red rockfish | 1400 | 1400 | 1260 | 87 |
| 1997 | Sharpchin/northern | 5810 | 4360 | 4360 | 1996 | Other red rockfish | 1400 | 1050 | 1050 | 164 |
| 1998 | Sharpchin/northern | 5640 | 4230 | 4230 | 3746 | Other red rockfish | 356 | 267 | 267 | 45 |
| 1999 | Sharpchin/northern | 5640 | 4230 | 4230 | 5492 | Other red rockfish | 356 | 267 | 267 | 157 |
| 2000 | Sharpchin/northern | 6870 | 5150 | 5150 | 5066 | Other red rockfish | 259 | 194 | 194 | 97 |

Table 2. Total allowable catch (TAC), acceptable biological catch (ABC), and catch of the species groups used to manage northern rockfish from 2001 to present in the eastern Bering Sea and Aleutian Islands.

| | | Bering Sea and Aleutian Islands | | | |
|---|---|---|---|---|---|
| Year | Management Group | OFL (t) | ABC (t) | TAC (t) | Catch (t) |
| 2001 | Sharpchin/northern | 9020 | 6764 | 6764 | 6488 |
| 2002 | Northern rockfish | 9020 | 6760 | 6760 | 4057 |
| 2003 | Northern rockfish | 9468 | 7101 | 6000 | 4929 |
| 2004 | Northern rockfish | 8140 | 6880 | 5000 | 4684 |
| 2005 | Northern rockfish | 9810 | 8260 | 5000 | 3964 |
| 2006 | Northern rockfish | 10100 | 8530 | 4500 | 3828 |
| 2007 | Northern rockfish | 9750 | 8190 | 8190 | 4016 |
| 2008 | Northern rockfish | 9740 | 8180 | 8180 | 3287 |
| 2009 | Northern rockfish | 8540 | 7160 | 7160 | 3111 |
| 2010 | Northern rockfish | 8640 | 7240 | 7240 | 4332 |
| 2011 | Northern rockfish | 10600 | 8670 | 4000 | 2763 |
| 2012 | Northern rockfish | 10500 | 8610 | 4700 | 2487 |
| 2013 | Northern rockfish | 12200 | 9850 | 3000 | 2037 |
| 2014 | Northern rockfish | 12077 | 9761 | 2594 | 2342 |
| 2015 | Northern rockfish | 15337 | 12488 | 3250 | 7197 |
| 2016 | Northern rockfish | 14689 | 11960 | 4500 | 4536 |
| 2017 | Northern rockfish | 16242 | 13264 | 5000 | 4697 |
| 2018 | Northern rockfish | 15888 | 12975 | 6100 | 5765 |
| 2019 | Northern rockfish | 15507 | 12664 | 6500 | 9092 |
| 2020 | Northern rockfish | 19751 | 16243 | 10000 | 8443 |
| 2021 | Northern rockfish | 18917 | 15557 | 13000 | 6212 |
| 2022 | Northern rockfish | 23420 | 19217 | 17000 | 7898 |
| 2023* | Northern rockfish | 22776 | 18687 | 11000 | 9948 |

*Catch data through September 16, 2023, from NMFS Alaska Regional Office.

Table 3. Catch of northern rockfish (t) by fishery and subregion in the BSAI area.

| | Eastern Bering Sea | | | Aleutian Islands | | | |
|---|---|---|---|---|---|---|---|
| Year | Foreign | Joint Venture | Domestic | Foreign | Joint Venture | Domestic | Total |
| 1977 | 5 | 0 | | 3,264 | 0 | | 3,270 |
| 1978 | 32 | 0 | | 3,655 | 0 | | 3,687 |
| 1979 | 46 | 0 | | 601 | 0 | | 647 |
| 1980 | 84 | 5 | | 549 | 0 | | 638 |
| 1981 | 35 | 0 | | 111 | 0 | | 145 |
| 1982 | 63 | 8 | | 177 | 0 | | 248 |
| 1983 | 10 | 32 | | 47 | 0 | | 89 |
| 1984 | 26 | 6 | | 11 | 185 | | 229 |
| 1985 | 5 | 1 | | 0 | 189 | | 195 |
| 1986 | 5 | 41 | 15 | 0 | 193 | 15 | 270 |
| 1987 | 1 | 45 | 31 | 0 | 248 | 60 | 385 |
| 1988 | 0 | 4 | 36 | 0 | 438 | 55 | 534 |
| 1989 | 0 | 12 | 66 | 0 | 0 | 306 | 384 |
| 1990 | | | 247 | | | 1,235 | 1,481 |
| 1991 | | | 626 | | | 233 | 859 |
| 1992 | | | 309 | | | 1,548 | 1,857 |
| 1993 | | | 859 | | | 4,530 | 5,389 |
| 1994 | | | 61 | | | 4,666 | 4,727 |
| 1995 | | | 266 | | | 3,858 | 4,124 |
| 1996 | | | 87 | | | 6,637 | 6,724 |
| 1997 | | | 164 | | | 1,996 | 2,161 |
| 1998 | | | 45 | | | 3,746 | 3,791 |
| 1999 | | | 157 | | | 5,492 | 5,650 |
| 2000 | | | 97 | | | 5,066 | 5,162 |
| 2001 | | | 180 | | | 6,309 | 6,488 |
| 2002 | | | 114 | | | 3,943 | 4,057 |
| 2003 | | | 67 | | | 4,862 | 4,929 |
| 2004 | | | 116 | | | 4,567 | 4,684 |
| 2005 | | | 112 | | | 3,852 | 3,964 |
| 2006 | | | 246 | | | 3,582 | 3,828 |
| 2007 | | | 70 | | | 3,946 | 4,016 |
| 2008 | | | 22 | | | 3,265 | 3,287 |
| 2009 | | | 48 | | | 3,064 | 3,111 |
| 2010 | | | 299 | | | 4,032 | 4,332 |
| 2011 | | | 197 | | | 2,566 | 2,763 |
| 2012 | | | 91 | | | 2,395 | 2,487 |
| 2013 | | | 138 | | | 1,900 | 2,038 |
| 2014 | | | 147 | | | 2,195 | 2,342 |
| 2015 | | | 199 | | | 6,998 | 7,197 |
| 2016 | | | 203 | | | 4,333 | 4,536 |
| 2017 | | | 225 | | | 4,472 | 4,697 |
| 2018 | | | 185 | | | 5,579 | 5,764 |
| 2019 | | | 492 | | | 8,601 | 9,092 |
| 2020 | | | 307 | | | 8,136 | 8,443 |
| 2021 | | | 329 | | | 5,883 | 6,212 |
| 2022 | | | 568 | | | 7,330 | 7,898 |
| 2023* | | | 1,001 | | | 8,947 | 9,948 |

*Catch data through September 16, 2023, from NMFS Alaska Regional Office.

Table 4. Area-specific catches of northern rockfish (t) in the BSAI area, obtained from the NMFS Alaska Regional Office.

| Year | WAI | CAI | EAI | EBS | Total |
|---|---|---|---|---|---|
| 1994 | 1,572 | 2,534 | 560 | 61 | 4,727 |
| 1995 | 1,421 | 1,641 | 796 | 266 | 4,124 |
| 1996 | 3,146 | 1,978 | 1,514 | 87 | 6,724 |
| 1997 | 1,287 | 490 | 219 | 164 | 2,161 |
| 1998 | 2,392 | 916 | 438 | 45 | 3,791 |
| 1999 | 3,185 | 1,104 | 1,203 | 157 | 5,650 |
| 2000 | 1,516 | 2,347 | 1,202 | 97 | 5,162 |
| 2001 | 3,725 | 1,840 | 743 | 180 | 6,488 |
| 2002 | 2,328 | 1,318 | 298 | 114 | 4,057 |
| 2003 | 2,506 | 1,994 | 361 | 67 | 4,929 |
| 2004 | 1,926 | 2,430 | 211 | 116 | 4,684 |
| 2005 | 1,822 | 1,759 | 271 | 112 | 3,964 |
| 2006 | 1,127 | 2,149 | 306 | 246 | 3,828 |
| 2007 | 974 | 1,821 | 1,151 | 70 | 4,016 |
| 2008 | 1,314 | 1,344 | 608 | 22 | 3,287 |
| 2009 | 1,191 | 1,315 | 558 | 48 | 3,111 |
| 2010 | 1,988 | 1,266 | 778 | 299 | 4,332 |
| 2011 | 311 | 1,351 | 905 | 197 | 2,763 |
| 2012 | 140 | 1,651 | 605 | 91 | 2,487 |
| 2013 | 115 | 1,308 | 478 | 138 | 2,038 |
| 2014 | 83 | 1,111 | 1,002 | 147 | 2,342 |
| 2015 | 3,346 | 1,600 | 2,052 | 199 | 7,197 |
| 2016 | 1,624 | 1,728 | 981 | 203 | 4,536 |
| 2017 | 1,776 | 2,013 | 683 | 225 | 4,697 |
| 2018 | 2,072 | 2,790 | 716 | 185 | 5,764 |
| 2019 | 5,106 | 1,763 | 1,732 | 492 | 9,092 |
| 2020 | 4,780 | 2,614 | 742 | 307 | 8,443 |
| 2021 | 3,457 | 1,903 | 523 | 329 | 6,212 |
| 2022 | 4,423 | 1,957 | 949 | 568 | 7,898 |
| 2023* | 5,424 | 1,621 | 1,902 | 1,001 | 9,948 |

* Estimated removals through September 16, 2023.

Table 5. Estimated retained, discarded, and percent discarded sharpchin/northern (SC/NO), and northern rockfish catch in the eastern Bering Sea (EBS) and Aleutian Islands (AI) regions. The catches of the SC/NO group consist nearly entirely of northern rockfish.

| | Aleutian Islands | | | | | Eastern Bering Sea | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Species Group | Retained | Discarded | Total | Percent Discarded | Species Group | Retained | Discarded | Total | Percent Discarded |
| 1993 | SC/NO | 317 | 4218 | 4535 | 93.00% | Other red rockfish | 367 | 97 | 464 | 20.92% |
| 1994 | SC/NO | 797 | 3870 | 4667 | 82.92% | Other red rockfish | 29 | 100 | 129 | 77.59% |
| 1995 | SC/NO | 1208 | 2665 | 3873 | 68.82% | Other red rockfish | 274 | 70 | 344 | 20.42% |
| 1996 | SC/NO | 2269 | 4384 | 6653 | 65.89% | Other red rockfish | 58 | 149 | 207 | 71.92% |
| 1997 | SC/NO | 145 | 1852 | 1997 | 92.74% | Other red rockfish | 44 | 174 | 218 | 80.02% |
| 1998 | SC/NO | 458 | 3288 | 3747 | 87.76% | Other red rockfish | 38 | 59 | 97 | 61.06% |
| 1999 | SC/NO | 735 | 4759 | 5493 | 86.63% | Other red rockfish | 75 | 163 | 238 | 68.33% |
| 2000 | SC/NO | 592 | 4492 | 5084 | 88.37% | Other red rockfish | 111 | 140 | 155 | 90.22% |
| 2001 | SC/NO | 403 | 5906 | 6309 | 93.62% | SC/NO | 15 | 164 | 180 | 91.11% |
| 2002 | Northerns | 347 | 3596 | 3943 | 91.19% | Northerns | 9 | 105 | 114 | 92.50% |
| 2003 | Northerns | 465 | 4397 | 4862 | 90.45% | Northerns | 17 | 51 | 67 | 75.22% |
| 2004 | Northerns | 686 | 3881 | 4567 | 84.97% | Northerns | 35 | 82 | 116 | 70.23% |
| 2005 | Northerns | 912 | 2940 | 3852 | 76.32% | Northerns | 45 | 67 | 112 | 59.56% |
| 2006 | Northerns | 965 | 2617 | 3582 | 73.06% | Northerns | 109 | 137 | 246 | 55.56% |
| 2007 | Northerns | 850 | 3096 | 3946 | 78.45% | Northerns | 23 | 46 | 70 | 66.46% |
| 2008 | Northerns | 1523 | 1742 | 3265 | 53.34% | Northerns | 8 | 14 | 22 | 64.25% |
| 2009 | Northerns | 1941 | 1122 | 3064 | 36.63% | Northerns | 40 | 8 | 48 | 15.90% |
| 2010 | Northerns | 3075 | 957 | 4032 | 23.74% | Northerns | 284 | 15 | 299 | 4.97% |
| 2011 | Northerns | 2442 | 124 | 2566 | 4.85% | Northerns | 167 | 30 | 197 | 15.23% |
| 2012 | Northerns | 2015 | 380 | 2395 | 15.88% | Northerns | 45 | 46 | 91 | 50.19% |
| 2013 | Northerns | 1719 | 181 | 1900 | 9.51% | Northerns | 104 | 34 | 138 | 24.46% |
| 2014 | Northerns | 2115 | 80 | 2195 | 3.66% | Northerns | 88 | 59 | 147 | 40.20% |
| 2015 | Northerns | 6619 | 379 | 6998 | 5.41% | Northerns | 127 | 72 | 199 | 36.37% |
| 2016 | Northerns | 4112 | 222 | 4333 | 5.12% | Northerns | 134 | 69 | 203 | 33.84% |
| 2017 | Northerns | 4191 | 281 | 4472 | 6.28% | Northerns | 181 | 44 | 225 | 19.58% |
| 2018 | Northerns | 5181 | 397 | 5579 | 7.12% | Northerns | 63 | 123 | 185 | 66.08% |
| 2019 | Northerns | 8196 | 405 | 8601 | 4.71% | Northerns | 407 | 84 | 492 | 17.14% |
| 2020 | Northerns | 7099 | 1037 | 8136 | 12.74% | Northerns | 232 | 75 | 307 | 24.29% |
| 2021 | Northerns | 5415 | 468 | 5883 | 7.95% | Northerns | 234 | 96 | 329 | 29.08% |
| 2022 | Northerns | 6763 | 567 | 7330 | 7.73% | Northerns | 500 | 68 | 568 | 12.01% |
| 2023* | Northerns | 8525 | 422 | 8947 | 4.71% | Northerns | 913 | 88 | 1001 | 8.76% |

* Estimated removals through September 16, 2023.

Table 6. Catch (t) of FMP groundfish species caught in BSAI trips targeting rockfish. "Conf" indicates confidential records with less than three vessels or processors. Source: Alaska Regional Office, via AKFIN 10/19/2023.

| Species Group Name | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Average |
|---|---|---|---|---|---|---|---|---|---|
| Pacific Ocean Perch | 19,589 | 20,422 | 21,091 | 27,651 | 25,802 | 23,637 | 23,415 | 20,481 | 22,761 |
| Atka Mackerel | 5,255 | 5,365 | 5,513 | 8,734 | 8,527 | 6,846 | 6,173 | 7,499 | 6,739 |
| Northern Rockfish | 1,338 | 1,476 | 1,768 | 4,527 | 3,512 | 2,193 | 3,133 | 4,891 | 2,855 |
| Pollock | 875 | 1,424 | 1,524 | 2,254 | 1,995 | 2,248 | 2,779 | 2,485 | 1,948 |
| Pacific Cod | 625 | 813 | 637 | 1,217 | 975 | 899 | 721 | 585 | 809 |
| Arrowtooth Flounder | 363 | 359 | 257 | 465 | 579 | 672 | 708 | 526 | 491 |
| BSAI Kamchatka Flounder | 463 | 427 | 322 | 518 | 714 | 549 | 305 | 512 | 476 |
| Sablefish | 14 | 143 | 147 | 286 | 370 | 475 | 707 | 595 | 342 |
| Other Rockfish | 129 | 163 | 198 | 342 | 405 | 284 | 355 | 339 | 277 |
| BSAI Skate and GOA Skate, Other | 139 | 144 | 165 | 294 | 282 | 216 | 174 | 133 | 193 |
| Rougheye Rockfish | 70 | 65 | 116 | 246 | 288 | 248 | 219 | 225 | 185 |
| Sculpin | 88 | 135 | 106 | 199 | 188 | | | | 143 |
| BSAI Other Flatfish | 16 | 52 | 88 | 157 | 141 | 161 | 248 | 176 | 130 |
| BSAI Shortraker Rockfish | 38 | 36 | 116 | 121 | 146 | 224 | 152 | 113 | 118 |
| Flathead Sole | 41 | 53 | 67 | 119 | 89 | 125 | 172 | 209 | 109 |
| Greenland Turbot | 28 | 37 | 53 | 119 | 165 | 115 | 91 | 168 | 97 |
| Rock Sole | 15 | 32 | 36 | 67 | 61 | 49 | 59 | 44 | 45 |
| Squid | 26 | 31 | 50 | | | | | | 35 |
| Shark | 2 | Conf | 2 | 2 | 4 | 2 | 6 | 3 | 3 |
| Octopus | 1 | 3 | 3 | 4 | 2 | 2 | 3 | 2 | 2 |
| Yellowfin Sole | 1 | 0 | 4 | 1 | 1 | 5 | 0 | | 2 |
| BSAI Alaska Plaice | Conf | | 1 | | 0 | Conf | Conf | | 0 |

Table 7. Catch (t) of BSAI northern rockfish by trip target fishery. "Conf" indicates confidential records with less than three vessels or processors. Source: Alaska Regional Office, via AKFIN 10/19/2023.

| Target | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Average |
|---|---|---|---|---|---|---|---|---|---|
| Atka Mackerel | 2941 | 3071 | 3865 | 4361 | 4681 | 3858 | 4502 | 4841 | 4015 |
| Rockfish | 1338 | 1476 | 1768 | 4527 | 3512 | 2193 | 3133 | 4891 | 2855 |
| Pollock - midwater | 109 | 48 | 70 | 78 | 107 | 72 | 23 | 32 | 67 |
| Pacific Cod | 83 | 67 | 48 | 66 | 63 | 72 | 36 | 25 | 58 |
| Kamchatka Flounder - BSAI | 1 | 20 | | 15 | 16 | 4 | 167 | 140 | 52 |
| Pollock - bottom | 45 | 14 | 8 | 37 | 51 | 1 | 23 | 16 | 24 |
| Flathead Sole | | | | 8 | | | | | 8 |
| Arrowtooth Flounder | 18 | | | | 3 | 1 | | 1 | 6 |
| Other Flatfish - BSAI | | 0 | | | | | | | 0 |
| Halibut | 0 | | 1 | 0 | 0 | | 0 | 0 | 0 |

Table 8. Bycatch (t) of PSC species by BSAI trip targeting rockfish, in tons for halibut and herring and 1000s of individuals for crab and salmon. “Source: Alaska Regional Office, via AKFIN 10/19/2023.

| Species Group Name | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Average |
|---|---|---|---|---|---|---|---|---|---|
| Bairdi Tanner Crab | 70.00 | 100.00 | 844.05 | 616.00 | 251.08 | 7660.05 | 704.18 | 4230.00 | 1809.42 |
| Blue King Crab | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 103.00 | 12.88 |
| Chinook Salmon | 211.00 | 577.00 | 274.00 | 1036.80 | 173.06 | 395.00 | 208.00 | 0.00 | 359.36 |
| Golden (Brown) King Crab | 5288.89 | 3016.00 | 4950.55 | 6298.29 | 3655.84 | 3300.53 | 3324.54 | 2787.72 | 4077.80 |
| Halibut | 24.98 | 51.18 | 44.16 | 86.00 | 59.64 | 81.93 | 73.87 | 52.58 | 59.29 |
| Herring | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0.58 | 0.51 |
| Non-Chinook Salmon | 185.00 | 124.00 | 764.00 | 1281.18 | 405.80 | 775.00 | 949.86 | 704.00 | 648.61 |
| Opilio Tanner (Snow) Crab | 17.00 | 73.00 | 14541.11 | 714.97 | 96.72 | 2313.00 | 142.00 | 577.00 | 2309.35 |
| Red King Crab | 58.13 | 631.00 | 477.08 | 327.00 | 63.23 | 206.04 | 0.00 | 102.00 | 233.06 |

Table 9. Bycatch (t) of non-FMP species by BSAI trip targeting rockfish. “Conf” indicates confidential records with less than three vessels or processors. Source: Alaska Regional Office, via AKFIN 10/19/2023.

| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|
| Giant Grenadier | 108.63 | 29.33 | 121.74 | 95.36 | 181.68 | 321.44 | 240.85 | 283.95 |
| Sculpin | | | | | | 96.57 | 145.76 | 148.52 |
| Misc fish | 58.93 | 107.35 | 74.95 | 104.32 | 78.92 | 55.68 | 51.04 | 55.54 |
| Sponge unidentified | 48.31 | 71.48 | 77.81 | 96.75 | 92.48 | 72.86 | 53.41 | 68.74 |
| Squid | | | | 23.41 | 56.42 | 75.80 | 79.23 | 113.13 |
| Sea star | 3.29 | 4.27 | 45.25 | 32.69 | 16.01 | 12.45 | 12.78 | 13.92 |
| Corals Bryozoans - Corals Bryozoans Unidentified | 11.15 | 26.61 | 5.89 | 23.56 | 9.25 | 5.23 | 9.45 | 9.55 |
| Grenadier - Rattail Grenadier Unidentified | | | Conf | 23.44 | | Conf | 3.25 | 3.84 |
| Eelpouts | 1.33 | 4.56 | 1.75 | 2.46 | 3.57 | 3.17 | 19.26 | 20.47 |
| Scypho jellies | 0.52 | 0.39 | 1.23 | 11.50 | 3.43 | 15.23 | 2.49 | 2.99 |
| Benthic urochordata | 0.18 | 0.32 | 2.88 | 12.16 | 6.08 | 0.46 | 0.40 | 0.85 |
| Brittle star unidentified | 0.12 | 0.14 | 5.02 | 3.21 | 6.08 | 3.27 | 1.13 | 3.57 |
| Sea anemone unidentified | 0.19 | 0.25 | 0.49 | 1.22 | 0.36 | 4.41 | 2.51 | 13.00 |
| Invertebrate unidentified | 1.86 | 0.13 | 0.16 | 4.86 | 1.69 | 8.62 | 0.32 | 0.44 |
| urchins dollars cucumbers | 0.37 | 1.14 | 2.10 | 2.64 | 0.69 | 1.05 | 3.94 | 6.05 |
| Greenlings | | Conf | Conf | 0.67 | 0.79 | 0.46 | 2.43 | 2.26 |
| Misc crabs | 0.40 | 0.24 | 0.28 | 1.00 | 0.30 | 0.35 | 5.11 | 2.60 |
| State-managed Rockfish | 0.62 | Conf | 0.36 | 0.34 | 1.13 | 0.46 | 0.58 | 2.64 |
| Snails | 0.13 | 0.31 | 0.81 | 0.80 | 0.79 | 0.76 | 0.80 | 1.32 |
| Pandalid shrimp | 0.15 | 0.10 | 0.32 | 0.14 | 0.16 | 0.38 | 0.53 | 0.31 |
| Misc crustaceans | 0.11 | 0.38 | 0.22 | 0.18 | 0.18 | 0.15 | 0.23 | 0.17 |
| Sea pens whips | 0.06 | Conf | 0.46 | 0.14 | 0.20 | 0.15 | 0.04 | 0.12 |
| Polychaete unidentified | Conf | | 0.02 | 0.03 | Conf | 0.00 | 0.01 | 0.43 |
| Bivalves | 0.05 | 0.02 | 0.05 | 0.15 | 0.03 | 0.17 | 0.07 | 0.21 |
| Lanternfishes (myctophidae) | Conf | Conf | 0.03 | 0.11 | Conf | 0.14 | 0.08 | 0.02 |
| Hermit crab unidentified | 0.02 | 0.01 | 0.04 | 0.10 | 0.04 | 0.08 | 0.15 | 0.13 |
| Misc inverts (worms etc) | Conf | | Conf | 0.00 | 0.03 | 0.01 | 0.01 | 0.01 |
| Other osmerids | | | Conf | Conf | Conf | 0.01 | | |
| Misc deep fish | Conf | | Conf | Conf | Conf | 0.01 | Conf | Conf |
| Stichaeidae | Conf | | 0.00 | | Conf | | | Conf |
| Birds - Auklets | | | Conf | | | | | |
| Birds - Black-footed Albatross | | | | | | | Conf | |
| Birds - Laysan Albatross | | | Conf | | | | | |
| Birds - Northern Fulmar | | | Conf | | | | Conf | |
| Birds - Shearwaters | | Conf | Conf | | | Conf | | Conf |
| Birds - Storm Petrels | | | Conf | | | Conf | | Conf |
| Pacific Sand lance | | | | | Conf | | | Conf |
| Saffron Cod | | | Conf | | | | | |
| Smelt (Family Osmeridae) | | | | | | | Conf | |

Table 10. Samples sizes of otoliths and lengths from fishery sampling, with the number of hauls from which these data were collected, from 1977-2022. Years where either age or length compositions were used in the assessment are shown in bold.

| Year | Lengths | Hauls | Otoliths collected | Hauls (read otoliths) | Otoliths read |
|---|---|---|---|---|---|
| 1977 | **1202** | 16 | 230 | 11 | 224 |
| 1978 | **759** | 11 | 148 | 16 | 148 |
| 1979 | | | | | |
| 1980 | | | | | |
| 1981 | | | | | |
| 1982 | 334 | 5 | | | |
| 1982 | | | | | |
| 1984 | 703 | 4 | | | |
| 1985 | 12 | 9 | 12 | 0 | 0 |
| 1986 | 100 | 2 | 100 | 0 | 0 |
| 1987 | 976 | 9 | 79 | 0 | 0 |
| 1988 | | | | | |
| 1989 | 80 | 1 | 80 | 0 | 0 |
| 1990 | 403 | 11 | | | |
| 1991 | 145 | 8 | | | |
| 1992 | | | | | |
| 1993 | 1809 | 16 | | | |
| 1994 | 767 | 8 | | | |
| 1995 | 833 | 14 | | | |
| 1996 | **4554** | 68 | | | |
| 1997 | 1 | 1 | | | |
| 1998 | **543** | 14 | 30 | 5 | 29 |
| 1999 | **917** | 42 | 50 | 0 | 0 |
| 2000 | 995 | 69 | 170 | 49 | **169** |
| 2001 | 661 | 70 | 136 | 58 | **135** |
| 2002 | 889 | 68 | 200 | 60 | **195** |
| 2003 | 1362 | 124 | 318 | 110 | **317** |
| 2004 | 842 | 78 | 198 | 69 | **196** |
| 2005 | 466 | 47 | 120 | 44 | **118** |
| 2006 | 895 | 73 | 231 | 71 | **230** |
| 2007 | 843 | 98 | 230 | 90 | **228** |
| 2008 | 897 | 127 | 256 | 125 | **255** |
| 2009 | 834 | 108 | 247 | 103 | **247** |
| 2010 | **1281** | 148 | 346 | | |
| 2011 | 1596 | 210 | 469 | 200 | **462** |
| 2012 | **1785** | 219 | 506 | | |
| 2013 | 2081 | 268 | 609 | 251 | **596** |
| 2014 | **1542** | 224 | 484 | | |
| 2015 | 3006 | 341 | 869 | 294 | **574** |
| 2016 | **2447** | 311 | 716 | | |
| 2017 | 3924 | 431 | 869 | 308 | **434** |
| 2018 | **5478** | 559 | 1148 | | |
| 2019 | 7998 | 761 | 1620 | 804 | **553** |
| 2020 | 6989 | 688 | 1474 | 591 | **434** |
| 2021 | 5678 | 696 | 1372 | 680 | **485** |
| 2022 | **6830** | 780 | 1578 | | |

Table 11. Estimated BSAI northern rockfish fishery length compositions.

| | Year | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Length (cm) | 1977 | 1978 | 1996 | 1998 | 1999 | 2010 | 2012 | 2014 | 2016 | 2018 | 2022 |
| 15 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 16 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 |
| 17 | 0.001 | 0.000 | 0.000 | 0.000 | 0.002 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.001 |
| 18 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 |
| 19 | 0.001 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 |
| 20 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.000 | 0.001 | 0.001 | 0.000 | 0.001 | 0.001 |
| 21 | 0.005 | 0.000 | 0.000 | 0.000 | 0.002 | 0.000 | 0.003 | 0.002 | 0.002 | 0.001 | 0.001 |
| 22 | 0.034 | 0.048 | 0.000 | 0.000 | 0.000 | 0.002 | 0.005 | 0.002 | 0.002 | 0.001 | 0.001 |
| 23 | 0.040 | 0.024 | 0.002 | 0.000 | 0.004 | 0.000 | 0.012 | 0.004 | 0.001 | 0.001 | 0.002 |
| 24 | 0.070 | 0.109 | 0.006 | 0.000 | 0.001 | 0.002 | 0.021 | 0.005 | 0.002 | 0.003 | 0.004 |
| 25 | 0.095 | 0.089 | 0.017 | 0.000 | 0.006 | 0.002 | 0.021 | 0.010 | 0.003 | 0.005 | 0.006 |
| 26 | 0.143 | 0.115 | 0.046 | 0.000 | 0.000 | 0.005 | 0.041 | 0.018 | 0.006 | 0.006 | 0.005 |
| 27 | 0.121 | 0.108 | 0.046 | 0.000 | 0.018 | 0.006 | 0.041 | 0.039 | 0.014 | 0.009 | 0.011 |
| 28 | 0.125 | 0.119 | 0.027 | 0.012 | 0.013 | 0.017 | 0.055 | 0.036 | 0.019 | 0.020 | 0.020 |
| 29 | 0.118 | 0.095 | 0.068 | 0.028 | 0.034 | 0.041 | 0.066 | 0.054 | 0.047 | 0.035 | 0.037 |
| 30 | 0.090 | 0.071 | 0.046 | 0.071 | 0.052 | 0.062 | 0.061 | 0.054 | 0.068 | 0.069 | 0.064 |
| 31 | 0.060 | 0.091 | 0.103 | 0.083 | 0.099 | 0.093 | 0.087 | 0.076 | 0.092 | 0.108 | 0.080 |
| 32 | 0.055 | 0.080 | 0.107 | 0.113 | 0.122 | 0.132 | 0.096 | 0.083 | 0.113 | 0.139 | 0.110 |
| 33 | 0.026 | 0.025 | 0.061 | 0.154 | 0.134 | 0.149 | 0.096 | 0.071 | 0.128 | 0.147 | 0.126 |
| 34 | 0.010 | 0.017 | 0.121 | 0.142 | 0.133 | 0.134 | 0.083 | 0.109 | 0.139 | 0.125 | 0.126 |
| 35 | 0.003 | 0.007 | 0.151 | 0.096 | 0.136 | 0.115 | 0.069 | 0.091 | 0.109 | 0.094 | 0.111 |
| 36 | 0.001 | 0.002 | 0.088 | 0.098 | 0.098 | 0.078 | 0.059 | 0.086 | 0.075 | 0.076 | 0.098 |
| 37 | 0.000 | 0.000 | 0.027 | 0.058 | 0.074 | 0.044 | 0.043 | 0.058 | 0.066 | 0.054 | 0.068 |
| 38+ | 0.001 | 0.000 | 0.084 | 0.145 | 0.069 | 0.117 | 0.138 | 0.198 | 0.115 | 0.105 | 0.129 |

Table 12. Estimated BSAI northern rockfish fishery age compositions.

| | Year | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2011 | 2013 | 2015 | 2017 | 2019 | 2020 | 2021 |
| 3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 4 | 0.031 | 0.000 | 0.007 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5 | 0.084 | 0.000 | 0.000 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.000 | 0.000 | 0.001 | 0.004 | 0.000 |
| 6 | 0.002 | 0.000 | 0.031 | 0.000 | 0.003 | 0.000 | 0.002 | 0.000 | 0.001 | 0.021 | 0.018 | 0.004 | 0.007 | 0.003 | 0.004 | 0.004 | 0.007 |
| 7 | 0.047 | 0.000 | 0.073 | 0.016 | 0.014 | 0.035 | 0.001 | 0.000 | 0.000 | 0.014 | 0.010 | 0.012 | 0.007 | 0.003 | 0.004 | 0.011 | 0.008 |
| 8 | 0.004 | 0.015 | 0.005 | 0.019 | 0.032 | 0.004 | 0.032 | 0.000 | 0.003 | 0.000 | 0.011 | 0.059 | 0.005 | 0.031 | 0.014 | 0.008 | 0.013 |
| 9 | 0.000 | 0.000 | 0.086 | 0.025 | 0.043 | 0.003 | 0.068 | 0.049 | 0.005 | 0.006 | 0.031 | 0.028 | 0.020 | 0.008 | 0.016 | 0.013 | 0.023 |
| 10 | 0.041 | 0.011 | 0.004 | 0.069 | 0.031 | 0.019 | 0.093 | 0.053 | 0.058 | 0.016 | 0.025 | 0.060 | 0.085 | 0.018 | 0.031 | 0.022 | 0.044 |
| 11 | 0.045 | 0.064 | 0.014 | 0.008 | 0.047 | 0.041 | 0.101 | 0.076 | 0.066 | 0.067 | 0.051 | 0.048 | 0.046 | 0.030 | 0.022 | 0.034 | 0.026 |
| 12 | 0.032 | 0.017 | 0.042 | 0.032 | 0.005 | 0.003 | 0.027 | 0.096 | 0.066 | 0.065 | 0.031 | 0.009 | 0.031 | 0.105 | 0.059 | 0.035 | 0.043 |
| 13 | 0.045 | 0.064 | 0.049 | 0.045 | 0.024 | 0.011 | 0.045 | 0.052 | 0.117 | 0.060 | 0.046 | 0.025 | 0.037 | 0.075 | 0.078 | 0.062 | 0.036 |
| 14 | 0.056 | 0.049 | 0.029 | 0.072 | 0.031 | 0.014 | 0.018 | 0.039 | 0.030 | 0.103 | 0.097 | 0.014 | 0.031 | 0.054 | 0.042 | 0.086 | 0.046 |
| 15 | 0.136 | 0.060 | 0.064 | 0.043 | 0.054 | 0.040 | 0.043 | 0.039 | 0.054 | 0.069 | 0.095 | 0.038 | 0.022 | 0.045 | 0.034 | 0.038 | 0.053 |
| 16 | 0.068 | 0.075 | 0.028 | 0.046 | 0.025 | 0.046 | 0.016 | 0.038 | 0.025 | 0.071 | 0.093 | 0.079 | 0.028 | 0.015 | 0.049 | 0.043 | 0.056 |
| 17 | 0.004 | 0.143 | 0.073 | 0.046 | 0.069 | 0.070 | 0.039 | 0.022 | 0.026 | 0.008 | 0.062 | 0.089 | 0.039 | 0.023 | 0.030 | 0.022 | 0.028 |
| 18 | 0.025 | 0.043 | 0.062 | 0.087 | 0.058 | 0.042 | 0.030 | 0.028 | 0.026 | 0.015 | 0.034 | 0.077 | 0.061 | 0.022 | 0.028 | 0.034 | 0.030 |
| 19 | 0.028 | 0.034 | 0.060 | 0.087 | 0.071 | 0.048 | 0.017 | 0.032 | 0.032 | 0.007 | 0.020 | 0.055 | 0.058 | 0.023 | 0.016 | 0.042 | 0.028 |
| 20 | 0.016 | 0.027 | 0.025 | 0.035 | 0.077 | 0.102 | 0.047 | 0.024 | 0.028 | 0.028 | 0.017 | 0.026 | 0.046 | 0.057 | 0.044 | 0.038 | 0.037 |
| 21 | 0.036 | 0.000 | 0.036 | 0.041 | 0.045 | 0.150 | 0.069 | 0.030 | 0.035 | 0.031 | 0.025 | 0.009 | 0.043 | 0.058 | 0.037 | 0.051 | 0.044 |
| 22 | 0.032 | 0.060 | 0.022 | 0.038 | 0.030 | 0.042 | 0.070 | 0.045 | 0.043 | 0.016 | 0.018 | 0.021 | 0.032 | 0.056 | 0.049 | 0.027 | 0.037 |
| 23 | 0.007 | 0.047 | 0.001 | 0.013 | 0.064 | 0.058 | 0.015 | 0.085 | 0.044 | 0.009 | 0.007 | 0.024 | 0.032 | 0.031 | 0.048 | 0.021 | 0.038 |
| 24 | 0.025 | 0.006 | 0.014 | 0.026 | 0.010 | 0.054 | 0.024 | 0.025 | 0.043 | 0.040 | 0.009 | 0.019 | 0.038 | 0.024 | 0.028 | 0.054 | 0.035 |
| 25 | 0.021 | 0.036 | 0.011 | 0.020 | 0.003 | 0.006 | 0.034 | 0.016 | 0.039 | 0.038 | 0.021 | 0.011 | 0.026 | 0.029 | 0.035 | 0.031 | 0.028 |
| 26 | 0.010 | 0.013 | 0.009 | 0.025 | 0.029 | 0.035 | 0.019 | 0.035 | 0.013 | 0.010 | 0.044 | 0.008 | 0.025 | 0.012 | 0.033 | 0.034 | 0.033 |
| 27 | 0.014 | 0.021 | 0.038 | 0.029 | 0.008 | 0.029 | 0.048 | 0.025 | 0.021 | 0.006 | 0.025 | 0.028 | 0.017 | 0.026 | 0.034 | 0.020 | 0.017 |
| 28 | 0.009 | 0.003 | 0.003 | 0.035 | 0.025 | 0.000 | 0.005 | 0.016 | 0.015 | 0.018 | 0.035 | 0.044 | 0.026 | 0.022 | 0.033 | 0.024 | 0.039 |
| 29 | 0.037 | 0.018 | 0.020 | 0.005 | 0.011 | 0.026 | 0.012 | 0.016 | 0.012 | 0.029 | 0.028 | 0.029 | 0.025 | 0.017 | 0.016 | 0.033 | 0.019 |
| 30 | 0.010 | 0.010 | 0.026 | 0.010 | 0.026 | 0.006 | 0.012 | 0.007 | 0.024 | 0.013 | 0.011 | 0.024 | 0.020 | 0.016 | 0.037 | 0.019 | 0.030 |
| 31 | 0.017 | 0.089 | 0.016 | 0.023 | 0.016 | 0.000 | 0.018 | 0.010 | 0.011 | 0.014 | 0.033 | 0.021 | 0.021 | 0.030 | 0.018 | 0.016 | 0.023 |
| 32 | 0.006 | 0.024 | 0.028 | 0.028 | 0.011 | 0.000 | 0.014 | 0.015 | 0.011 | 0.008 | 0.009 | 0.004 | 0.030 | 0.019 | 0.009 | 0.037 | 0.016 |
| 33 | 0.021 | 0.006 | 0.036 | 0.005 | 0.038 | 0.000 | 0.010 | 0.005 | 0.017 | 0.015 | 0.005 | 0.017 | 0.016 | 0.012 | 0.022 | 0.023 | 0.013 |
| 34 | 0.007 | 0.016 | 0.004 | 0.013 | 0.017 | 0.000 | 0.004 | 0.010 | 0.015 | 0.008 | 0.007 | 0.005 | 0.016 | 0.020 | 0.013 | 0.008 | 0.017 |
| 35 | 0.022 | 0.006 | 0.011 | 0.005 | 0.011 | 0.032 | 0.008 | 0.000 | 0.048 | 0.017 | 0.007 | 0.013 | 0.009 | 0.009 | 0.013 | 0.023 | 0.015 |
| 36 | 0.015 | 0.009 | 0.004 | 0.009 | 0.012 | 0.009 | 0.004 | 0.018 | 0.000 | 0.028 | 0.011 | 0.014 | 0.012 | 0.016 | 0.008 | 0.012 | 0.012 |
| 37 | 0.008 | 0.010 | 0.001 | 0.000 | 0.000 | 0.001 | 0.009 | 0.015 | 0.003 | 0.006 | 0.009 | 0.012 | 0.011 | 0.015 | 0.015 | 0.015 | 0.015 |
| 38 | 0.007 | 0.012 | 0.004 | 0.004 | 0.000 | 0.000 | 0.003 | 0.016 | 0.003 | 0.009 | 0.002 | 0.005 | 0.013 | 0.007 | 0.009 | 0.003 | 0.016 |
| 39 | 0.002 | 0.000 | 0.012 | 0.000 | 0.004 | 0.010 | 0.000 | 0.008 | 0.015 | 0.008 | 0.005 | 0.009 | 0.008 | 0.000 | 0.006 | 0.002 | 0.002 |
| 40+ | 0.028 | 0.011 | 0.052 | 0.039 | 0.054 | 0.064 | 0.042 | 0.052 | 0.051 | 0.122 | 0.048 | 0.056 | 0.061 | 0.068 | 0.066 | 0.045 | 0.073 |

Table 13. Northern rockfish biomass estimates (t) from Aleutian Islands trawl survey, with coefficients of variation shown in parentheses.

| | Aleutian Islands Survey | | | | |
|---|---|---|---|---|---|
| Year | Western | Central | Eastern | southern BS | Total AI survey |
| 1980 | 3,024 (0.98) | 316 (0.63) | 34,170 (0.99) | 83 (0.95) | 37,593 (0.90) |
| 1983 | 34,361 (0.21) | 9,106 (0.48) | 11,765 (0.10) | 1,136 (0.57) | 56,368 (0.15) |
| 1986 | 20,691 (0.44) | 105,608 (0.44) | 4,014 (0.55) | 10,092 (0.64) | 140,405 (0.34) |
| 1991 | 144,043 (0.21) | 64,119 (0.18) | 4,068 (0.52) | 582 (0.63) | 212,813 (0.15) |
| 1994 | 65,843 (0.65) | 15,832 (0.58) | 5,933 (0.54) | 855 (0.60) | 88,463 (0.50) |
| 1997 | 65,493 (0.38) | 18,363 (0.55) | 3,331 (0.58) | 204 (0.68) | 87,391 (0.31) |
| 2000 | 142,393 (0.39) | 37,949 (0.44) | 24,982 (0.70) | 49 (0.40) | 205,373 (0.29) |
| 2002 | 136,440 (0.33) | 38,819 (0.43) | 3,242 (0.42) | 290 (0.67) | 178,791 (0.27) |
| 2004 | 146,179 (0.27) | 26,913 (0.39) | 10,375 (0.37) | 5,980 (0.93) | 189,446 (0.22) |
| 2006 | 102,651 (0.29) | 70,834 (0.51) | 22,982 (0.45) | 22,883 (1.00) | 219,350 (0.24) |
| 2010 | 143,953 (0.29) | 51,331 (0.40) | 21,847 (0.50) | 189 (0.52) | 217,319 (0.22) |
| 2012 | 216,325 (0.65) | 52,674 (0.40) | 15,615 (0.60) | 550 (0.73) | 285,164 (0.50) |
| 2014 | 346,392 (0.38) | 48,049 (0.44) | 76,787 (0.79) | 1,668 (0.80) | 472,895 (0.31) |
| 2016 | 124,310 (0.21) | 78,869 (0.37) | 48,382 (0.52) | 1,656 (0.55) | 253,217 (0.18) |
| 2018 | 98,756 (0.24) | 54,500 (0.40) | 20,096 (0.63) | 34,120 (0.70) | 212,472 (0.20) |
| 2022 | 122,692 (0.24) | 32,212 (0.46) | 73,986 (0.47) | 58,425 (0.76) | 287,315 (0.23) |

Table 14. Estimated age compositions from the Aleutian Islands trawl survey.

| | Year | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | 1991 | 1994 | 1997 | 2000 | 2002 | 2004 | 2006 | 2010 | 2012 | 2014 | 2016 | 2018 | 2022 |
| 3 | 0.000 | 0.000 | 0.004 | 0.009 | 0.000 | 0.000 | 0.005 | 0.002 | 0.001 | 0.000 | 0.000 | 0.001 | 0.000 |
| 4 | 0.000 | 0.000 | 0.022 | 0.027 | 0.010 | 0.001 | 0.011 | 0.006 | 0.004 | 0.000 | 0.000 | 0.002 | 0.001 |
| 5 | 0.014 | 0.017 | 0.013 | 0.030 | 0.016 | 0.011 | 0.007 | 0.034 | 0.001 | 0.003 | 0.003 | 0.000 | 0.000 |
| 6 | 0.035 | 0.016 | 0.034 | 0.017 | 0.035 | 0.004 | 0.011 | 0.041 | 0.010 | 0.004 | 0.002 | 0.001 | 0.027 |
| 7 | 0.128 | 0.017 | 0.035 | 0.029 | 0.026 | 0.017 | 0.009 | 0.017 | 0.032 | 0.003 | 0.029 | 0.001 | 0.015 |
| 8 | 0.052 | 0.039 | 0.181 | 0.007 | 0.113 | 0.053 | 0.010 | 0.025 | 0.020 | 0.010 | 0.031 | 0.000 | 0.027 |
| 9 | 0.021 | 0.074 | 0.080 | 0.010 | 0.099 | 0.057 | 0.053 | 0.010 | 0.025 | 0.048 | 0.021 | 0.012 | 0.018 |
| 10 | 0.090 | 0.116 | 0.031 | 0.053 | 0.038 | 0.063 | 0.066 | 0.014 | 0.013 | 0.042 | 0.030 | 0.032 | 0.009 |
| 11 | 0.036 | 0.012 | 0.027 | 0.105 | 0.034 | 0.041 | 0.074 | 0.020 | 0.010 | 0.019 | 0.061 | 0.018 | 0.017 |
| 12 | 0.035 | 0.020 | 0.105 | 0.032 | 0.041 | 0.043 | 0.043 | 0.036 | 0.014 | 0.028 | 0.035 | 0.037 | 0.064 |
| 13 | 0.061 | 0.040 | 0.056 | 0.035 | 0.061 | 0.013 | 0.031 | 0.034 | 0.027 | 0.017 | 0.031 | 0.046 | 0.015 |
| 14 | 0.053 | 0.007 | 0.028 | 0.048 | 0.061 | 0.041 | 0.035 | 0.043 | 0.043 | 0.022 | 0.008 | 0.036 | 0.034 |
| 15 | 0.027 | 0.072 | 0.010 | 0.050 | 0.040 | 0.059 | 0.027 | 0.054 | 0.024 | 0.010 | 0.010 | 0.020 | 0.029 |
| 16 | 0.032 | 0.060 | 0.012 | 0.054 | 0.044 | 0.047 | 0.035 | 0.036 | 0.029 | 0.019 | 0.006 | 0.009 | 0.024 |
| 17 | 0.017 | 0.037 | 0.011 | 0.017 | 0.026 | 0.042 | 0.041 | 0.017 | 0.033 | 0.024 | 0.017 | 0.008 | 0.050 |
| 18 | 0.034 | 0.023 | 0.012 | 0.002 | 0.006 | 0.035 | 0.015 | 0.022 | 0.030 | 0.038 | 0.041 | 0.012 | 0.043 |
| 19 | 0.024 | 0.027 | 0.020 | 0.021 | 0.000 | 0.022 | 0.024 | 0.015 | 0.033 | 0.058 | 0.029 | 0.018 | 0.026 |
| 20 | 0.028 | 0.053 | 0.018 | 0.016 | 0.016 | 0.046 | 0.033 | 0.024 | 0.033 | 0.033 | 0.041 | 0.035 | 0.016 |
| 21 | 0.022 | 0.024 | 0.004 | 0.039 | 0.016 | 0.022 | 0.029 | 0.027 | 0.027 | 0.054 | 0.044 | 0.054 | 0.015 |
| 22 | 0.035 | 0.029 | 0.005 | 0.020 | 0.005 | 0.013 | 0.030 | 0.021 | 0.020 | 0.046 | 0.023 | 0.066 | 0.020 |
| 23 | 0.034 | 0.014 | 0.010 | 0.019 | 0.001 | 0.032 | 0.009 | 0.015 | 0.015 | 0.015 | 0.031 | 0.046 | 0.048 |
| 24 | 0.043 | 0.047 | 0.010 | 0.011 | 0.030 | 0.012 | 0.022 | 0.017 | 0.031 | 0.036 | 0.028 | 0.022 | 0.041 |
| 25 | 0.034 | 0.024 | 0.033 | 0.008 | 0.027 | 0.013 | 0.015 | 0.042 | 0.031 | 0.043 | 0.034 | 0.035 | 0.051 |
| 26 | 0.022 | 0.015 | 0.032 | 0.031 | 0.014 | 0.012 | 0.017 | 0.029 | 0.026 | 0.036 | 0.022 | 0.044 | 0.037 |
| 27 | 0.005 | 0.011 | 0.026 | 0.035 | 0.018 | 0.031 | 0.019 | 0.015 | 0.040 | 0.021 | 0.041 | 0.028 | 0.022 |
| 28 | 0.010 | 0.026 | 0.013 | 0.021 | 0.019 | 0.021 | 0.017 | 0.027 | 0.034 | 0.025 | 0.032 | 0.044 | 0.017 |
| 29 | 0.017 | 0.000 | 0.015 | 0.018 | 0.000 | 0.029 | 0.018 | 0.004 | 0.011 | 0.024 | 0.023 | 0.022 | 0.021 |
| 30 | 0.016 | 0.009 | 0.022 | 0.047 | 0.000 | 0.025 | 0.028 | 0.004 | 0.007 | 0.020 | 0.022 | 0.021 | 0.038 |
| 31 | 0.013 | 0.010 | 0.007 | 0.047 | 0.007 | 0.006 | 0.030 | 0.014 | 0.007 | 0.016 | 0.043 | 0.038 | 0.024 |
| 32 | 0.000 | 0.006 | 0.004 | 0.002 | 0.023 | 0.024 | 0.026 | 0.028 | 0.023 | 0.015 | 0.028 | 0.023 | 0.018 |
| 33 | 0.010 | 0.028 | 0.004 | 0.006 | 0.011 | 0.021 | 0.012 | 0.036 | 0.033 | 0.023 | 0.018 | 0.027 | 0.041 |
| 34 | 0.000 | 0.019 | 0.007 | 0.008 | 0.000 | 0.032 | 0.027 | 0.015 | 0.020 | 0.018 | 0.017 | 0.026 | 0.011 |
| 35 | 0.004 | 0.007 | 0.002 | 0.011 | 0.007 | 0.015 | 0.018 | 0.013 | 0.017 | 0.031 | 0.009 | 0.014 | 0.014 |
| 36 | 0.000 | 0.000 | 0.009 | 0.018 | 0.000 | 0.010 | 0.022 | 0.041 | 0.021 | 0.010 | 0.019 | 0.016 | 0.020 |
| 37 | 0.000 | 0.020 | 0.022 | 0.019 | 0.000 | 0.002 | 0.018 | 0.019 | 0.017 | 0.008 | 0.027 | 0.021 | 0.017 |
| 38 | 0.008 | 0.000 | 0.010 | 0.016 | 0.043 | 0.008 | 0.005 | 0.022 | 0.019 | 0.025 | 0.012 | 0.016 | 0.008 |
| 39 | 0.007 | 0.000 | 0.002 | 0.007 | 0.010 | 0.002 | 0.025 | 0.016 | 0.014 | 0.016 | 0.012 | 0.017 | 0.008 |
| 40+ | 0.034 | 0.081 | 0.063 | 0.057 | 0.100 | 0.074 | 0.082 | 0.145 | 0.204 | 0.141 | 0.120 | 0.132 | 0.115 |

Table 15. Sample sizes of otoliths and length measurement from the AI trawl survey, 1991-2022, with the number of hauls from which these data were collected.

| Year | Lengths | Hauls | Otoliths read | Hauls |
|---|---|---|---|---|
| 1980 | 3351 | 31 | 473 | 4 |
| 1983 | 6535 | 71 | 625 | 11 |
| 1986 | 5881 | 41 | 565 | 18 |
| 1991 | 4853 | 47 | 456 | 14 |
| 1994 | 6252 | 118 | 409 | 19 |
| 1997 | 7554 | 153 | 652 | 68 |
| 2000 | 7779 | 135 | 725 | 92 |
| 2002 | 9459 | 153 | 259 | 69 |
| 2004 | 12176 | 201 | 515 | 65 |
| 2006 | 8404 | 160 | 535 | 57 |
| 2010 | 11796 | 198 | 538 | 72 |
| 2012 | 10523 | 188 | 576 | 67 |
| 2014 | 14884 | 209 | 550 | 60 |
| 2016 | 15116 | 240 | 576 | 146 |
| 2018 | 14640 | 230 | 588 | 140 |
| 2022 | 10782 | 205 | 647 | 135 |

Table 16. Sample sizes of read otoliths by area and year in the Aleutian Islands surveys.

| Year | Western AI | Central AI | Eastern AI | Southern Bering Sea | Total |
|---|---|---|---|---|---|
| 1980 | 201 | 92 | 180 | | 473 |
| 1983 | 268 | 225 | 93 | 39 | 625 |
| 1986 | 132 | 293 | 25 | 115 | 565 |
| 1991 | | 243 | 159 | 54 | 456 |
| 1994 | 180 | 61 | 127 | 41 | 409 |
| 1997 | 234 | 219 | 199 | | 652 |
| 2000 | 229 | 275 | 200 | 21 | 725 |
| 2002 | 88 | 74 | 66 | 31 | 259 |
| 2004 | 193 | 156 | 120 | 46 | 515 |
| 2006 | 197 | 148 | 113 | 77 | 535 |
| 2010 | 195 | 186 | 139 | 18 | 538 |
| 2012 | 206 | 156 | 160 | 54 | 576 |
| 2014 | 201 | 147 | 150 | 52 | 550 |
| 2016 | 288 | 167 | 106 | 15 | 576 |
| 2018 | 289 | 150 | 119 | 30 | 588 |
| 2022 | 284 | 191 | 147 | 25 | 647 |

Table 17. Average of predicted weight (kg, from 2016 – 2022 from AI trawl survey data, and from 2017-2021 from the fishery), and proportion mature at age for BSAI northern rockfish.

| | Predicted weight (g) | | Proportion |
|---|---|---|---|
| Age | AI Survey (2016-2022) | Fishery (2017-2021) | mature |
| 3 | 63 | 123 | 0.026 |
| 4 | 96 | 165 | 0.050 |
| 5 | 133 | 209 | 0.096 |
| 6 | 172 | 252 | 0.176 |
| 7 | 209 | 294 | 0.301 |
| 8 | 246 | 333 | 0.464 |
| 9 | 280 | 369 | 0.636 |
| 10 | 311 | 401 | 0.779 |
| 11 | 340 | 431 | 0.876 |
| 12 | 366 | 457 | 0.934 |
| 13 | 389 | 480 | 0.966 |
| 14 | 410 | 501 | 0.983 |
| 15 | 428 | 519 | 0.991 |
| 16 | 444 | 535 | 0.996 |
| 17 | 458 | 549 | 0.998 |
| 18 | 471 | 561 | 0.999 |
| 19 | 482 | 571 | 0.999 |
| 20 | 492 | 581 | 1 |
| 21 | 500 | 589 | 1 |
| 22 | 507 | 596 | 1 |
| 23 | 514 | 602 | 1 |
| 24 | 520 | 607 | 1 |
| 25 | 525 | 612 | 1 |
| 26 | 529 | 616 | 1 |
| 27 | 533 | 619 | 1 |
| 28 | 536 | 622 | 1 |
| 29 | 539 | 625 | 1 |
| 30 | 542 | 627 | 1 |
| 31 | 544 | 629 | 1 |
| 32 | 546 | 631 | 1 |
| 33 | 548 | 632 | 1 |
| 34 | 549 | 633 | 1 |
| 35 | 551 | 635 | 1 |
| 36 | 552 | 636 | 1 |
| 37 | 553 | 636 | 1 |
| 38 | 554 | 637 | 1 |
| 39 | 555 | 638 | 1 |
| 40 | 555 | 638 | 1 |

Table 18. Parameters and quantities for the BSAI northern rockfish model, with values where fixed or specified.

| Parameter | Description | Value(s) |
|---|---|---|
| $Y$ | Year | 1977, . . . , 2023 |
| $N$ | Population abundance | |
| $a$ | Age classes | |
| $a_r$ | Age of recruitment | 3 |
| $A$ | Plus-group age | 40 |
| $l$ | Length classes | 15, . . ., 38+ |
| $w_{y,a}^{p}$ | Vector of population weight-at-age by year (kg) | |
| $w_{y,a}^{f}$ | Vector of fishery weight-at-age by year (kg) | |
| $m_a$ | Vector of maturity-at-age | |
| $\mu_r$ | Average annual recruitment, log-scale | |
| $\mu_{init}$ | Average annual recruitment, log-scale, cohorts in initial year | |
| $\mu_f$ | Average fishing mortality | |
| $\varepsilon_y$ | Annual fishing mortality deviation, log-scale | |
| $\tau_y$ | Annual recruitment deviation | |
| $\gamma_y$ | Annual recruitment deviation, cohorts in first year | |
| $\sigma_R$ | Recruitment variability | 0.75 |
| $s_a^f$ | Vector of selectivity-at-age for fishery | |
| $s_a^f$ | Vector of selectivity-at-age for survey | |
| $M$ | Natural mortality | |
| $F_{y,a}$ | Fishing mortality for year *y* and age class *a* | |
| $Z_{y,a}$ | Total mortality for year *y* and age class *a* | |
| *SB_frac* | Spawning month as fraction of year | 0.25 |

Table 18 (continued). Parameters and quantities for the BSAI northern rockfish model, with values where fixed or specified.

| Parameter | Description | Value(s) |
|---|---|---|
| $T_{a\to a'}$ | Aging error matrix | |
| $T_{a\to l}$ | Age to length conversion matrix | |
| $q$ | Trawl survey catchability | |
| $SB_y$ | Spawning biomass in year $y$ ($=m_a\ w_a\ N_{y,a}$) | |
| $M_{prior}$ | Prior mean for natural mortality | 0.06 |
| $q_{prior}$ | Prior mean for trawl survey catchability | 1.0 |
| $\sigma_M$ | Prior log-scale standard deviation for natural mortality | 0.15 |
| $\sigma_q$ | Prior log-scale standard deviation for trawl survey catchability | 0.001 |
| $\sigma_s$ | Prior standard deviation for trawl survey selectivity constraint | 0.003 |
| $n_y^{f,a}, n_y^{f,l}, n_y^{t,a}$ | First-stage input sample sizes for fishery length and age compositions, and survey age compositions (number of hauls) | |
| $\lambda_{\hat{p}_a^f}, \lambda_{\hat{p}_l^f}, \lambda_{\hat{p}_a^t}$ | Second-stage weights for fishery length and age compositions, and survey age compositions (from Francis weighting) | |
| $\lambda_{\hat{C}}$, | Weight for catch likelihood | 200 |
| $\lambda_{\hat{I}}$ | Weight for survey index | 1 |
| $\lambda_f$ | Weight for *F* fishing mortality deviations | 0.1 |

Table 19. Equations for modeling the population dynamics and observed data for BSAI northern rockfish, see Table 18 for definitions.

| Equations describing population dynamics | |
|---|---|
| $N_{y,3} = \begin{cases} e^{\mu_r + \tau_y} & 1977 \le y \le 2020 \\ e^{\mu_r + \sigma_r^2/2} & 2021 \le y \le 2023 \end{cases}$ | Number at age of recruitment |
| $N_{styr,a} = \begin{cases} e^{\mu_{init} - M(a-a_r) + \gamma_{a-a_r+1}} & a_r < a < A \\ \frac{e^{\mu_{init} - M(A-a_r) + \gamma_{A-a_r+1}}}{(1-e^{-M})}, & a = A \end{cases}$ | Numbers at age, start year |
| $N_{y,a} = \begin{cases} N_{y-1,a-1} e^{-Z_{y-1,a-1}} & a_r < a < A \\ N_{y-1,a-1} e^{-Z_{y-1,a-1}} + N_{y-1,a} e^{-Z_{y-1,a}} & a = A \end{cases}$ | Numbers at age, subsequent years |
| $s_a^f = \left(1 + e^{-\delta^f (a - a_{50\%}^f}\right)^{-1}$ | Fishery selectivity |
| $F_{y,a} = s_a^f e^{\mu_f + \varepsilon_y}$ | Fishing mortality |
| $Z_{y,a} = Z_{y,a} + M$ | Total mortality |
| $SSB_{y,a} = 0.5 N_{y,a} m_a w_{y,a}^p e^{-SB_{frac} * Z_{y,a}}$ | Spawning biomass |

| Equations describing the observed data | |
|---|---|
| $\bar{N}_{y,a} = N_{y,a}(1 - e^{-Z_{y,a}})/Z_{y,a}$ | Mean numbers at age |
| $\hat{C}_{y,a} = F_{y,a} \bar{N}_{y,a}$ | Estimated catch numbers at age |
| $\hat{Y}_t = \sum_{a=a_r}^{A} w_a \hat{C}_{y,a}$ | Estimated catch biomass |
| $s_a^t = \left(1 + e^{-\delta^t (a - a_{50\%}^t}\right)^{-1}$ | AI trawl survey selectivity |
| $\hat{I}_{t,y} = q \sum_{a=a_r}^{A} w_a s_a^t \bar{N}_{y,a}$ | Estimated trawl survey biomass |
| $\hat{p}_{y,a}^t = T_{a \to a'} \frac{s_a^t \bar{N}_{y,a}}{\sum_{a=a_r}^{A} s_a^t \bar{N}_{y,a}}$ | Estimated trawl survey age compositon |
| $\hat{p}_{y,l}^f = T_{a \to l} \frac{\hat{C}_{y,a}}{\sum_{a=a_r}^{A} \hat{C}_{y,a}}$ | Estimated fishery length compositon |
| $\hat{p}_{y,a}^f = T_{a \to a'} \frac{\hat{C}_{y,a}}{\sum_{a=a_r}^{A} \hat{C}_{y,a}}$ | Estimated fishery age compositon |
| $\hat{m}_a = \left(1 + e^{-\delta^m (a - a_{50\%}^m}\right)^{-1}$ | Estimated maturity at age |

Table 20. Equations for likelihood components for the BSAI northern rockfish model, see Tables 18-19 for definitions.

| Negative log likelihood, data components | |
|---|---|
| $L_{\hat{c}} = \lambda_{\hat{c}} \sum_{Y} ln\left(\frac{Y_y + 0.001}{\hat{Y}_y + 0.001}\right)^2$ | Catch likelihood |
| $L_{\hat{I}} = \lambda_{\hat{I}} \sum_{Y} \frac{1}{2(\sigma_{I,y}/I_y)} ln\left(\frac{I_y}{\hat{I}_y}\right)^2$ | Trawl survey biomass likelihood |
| $L_{\hat{p}_a^f} = \lambda_{\hat{p}_a^f}\left(\sum_{Y} -n_y^{f,a} \sum_{a=a_r}^{A} \left(p_{y,a}^f + 0.00001\right) ln\left(\hat{p}_{y,a}^f + 0.00001\right)\right)$ | Fishery age compostion likelihood |
| $L_{\hat{p}_l^f} = \lambda_{\hat{p}_l^f}\left(\sum_{Y} -n_y^{f,l} \sum_{L} \left(p_{y,l}^f + 0.00001\right) ln\left(\hat{p}_{y,l}^f + 0.00001\right)\right)$ | Fishery length compostion likelihood |
| $L_{\hat{p}_a^t} = \lambda_{\hat{p}_a^t}\left(\sum_{Y} -n_y^{t,a} \sum_{a=a_r}^{A} \left(p_{y,a}^t + 0.00001\right) ln\left(\hat{p}_{y,a}^t + 0.00001\right)\right)$ | Trawl survey age compostion likelihood |
| $L_m = \sum_{D} \sum_{a=a_r}^{A} -\lambda_{D,a} \ln\left(Binom\left(n_{a,D}, \widehat{m}_a\right)\right)$ | Maturity likelihood |

| Negative log likelihoods, prior distributions and penalties | |
|---|---|
| $L_r = \frac{1}{2\sigma_r^2} \sum_{Y} \left(\tau_y + \sigma_r^2/2\right)^2 + Y \ln \sigma_r$ | Recruitment deviations |
| $L_r = \frac{1}{2\sigma_r^2} \sum_{A} \left(\gamma_y\right)^2 + A \ln \sigma_r$ | Recruitment deviations for cohorts in first ye |
| $L_M = \frac{1}{2\sigma_M^2}\left(\ln\theta - \ln M_{prior} + \sigma_M^2/2\right)^2$ | Prior distribution for natural mortality |
| $L_q = \frac{1}{2\sigma_q^2}\left(\ln\theta - \ln q_{prior} + \sigma_q^2/2\right)^2$ | Prior distribution for survey catchability |
| $L_f = \lambda_f \sum_{Y} \epsilon_y^2$ | $F$ deviation penalty |
| $L_s = \frac{1}{2\sigma_s^2}\left(s_{30}^t - 1\right)^2$ | Survey selectivity constraint |

Table 21. Negative log likelihood of model components, root mean squared errors, and estimates and standard deviations of key quantities.

| | Model 21 (2021) | Model 21 (2023) |
|---|---|---|
| **Negative log-likelihood** | | |
| *Data components* | | |
| AI survey biomass | 8.43 | 8.77 |
| Catch biomass | 0.00 | 0.00 |
| Fishery age comp | 237.93 | 257.77 |
| Fishery length comp | 75.33 | 84.10 |
| AI survey age comp | 172.67 | 198.34 |
| Maturity | 7.21 | 7.21 |
| *Priors and penalties* | | |
| Recruitment | -5.72 | -2.91 |
| Prior on survey q | 0.00 | 0.00 |
| Prior on M | 0.23 | 0.35 |
| penalty on survey sel | 1.61 | 1.54 |
| Fishing mortality penalty | 5.73 | 5.91 |
| Total negative log-likelihood | 503.42 | 561.08 |
| Parameters | 135 | 139 |
| **Root mean square error** | | |
| AI survey biomass | 0.375 | 0.355 |
| Recruitment | 0.571 | 0.622 |
| Fishery age comp | 0.015 | 0.015 |
| Fishery length comp | 0.030 | 0.029 |
| AI survey age comp | 0.017 | 0.016 |
| **Estimated key quantities** | | |
| *M* | 0.054 | 0.052 |
| standard deviation | 0.005 | 0.004 |
| CV | 0.088 | 0.085 |
| *2023 total biomass* | | 308,010 |
| standard deviation | | 32,138 |
| CV | | 0.10 |

Table 22. Estimated parameter values and standard deviations for Model 21 (2023).

| Parameter | Estimate | Standard Deviation | parameter | estimate | Standard Deviation | parameter | estimate | Standard Deviation |
|---|---|---|---|---|---|---|---|---|
| sel_aslope_fish | 0.7841 | 0.0632 | fmort_dev | 0.7467 | 0.0902 | rec_dev | -0.2195 | 0.4260 |
| sel_a50_fish | 9.2416 | 0.2348 | fmort_dev | 1.2435 | 0.0947 | rec_dev | -0.2137 | 0.4592 |
| sel_aslope_srv | 0.2802 | 0.0179 | fmort_dev | 1.2135 | 0.0995 | rec_dev | -0.1333 | 0.4794 |
| sel_a50_srv | 11.2850 | 0.5371 | fmort_dev | 0.9329 | 0.1043 | rec_dev | -0.6850 | 0.5699 |
| M | 0.0523 | 0.0044 | fmort_dev | 1.2033 | 0.1093 | mean_log_r | 3.8100 | 0.1014 |
| log_avg_fmort | -4.8491 | 0.0754 | fmort_dev | 1.4756 | 0.1148 | log_rinit | 3.0662 | 0.2473 |
| fmort_dev | 1.0327 | 0.1241 | rec_dev | -0.0047 | 0.6366 | fydev | 0.1371 | 0.7644 |
| fmort_dev | 1.1064 | 0.1180 | rec_dev | -0.1262 | 0.6410 | fydev | 0.2967 | 0.8587 |
| fmort_dev | -0.7029 | 0.1101 | rec_dev | -0.1097 | 0.6514 | fydev | 0.3948 | 0.9770 |
| fmort_dev | -0.7969 | 0.1032 | rec_dev | 0.0449 | 0.6746 | fydev | 2.1133 | 0.5131 |
| fmort_dev | -2.3454 | 0.0983 | rec_dev | 0.2253 | 0.6637 | fydev | 0.2746 | 0.8804 |
| fmort_dev | -1.8605 | 0.0942 | rec_dev | 0.0662 | 0.6554 | fydev | 0.1954 | 0.8080 |
| fmort_dev | -2.9249 | 0.0901 | rec_dev | -0.1197 | 0.6186 | fydev | 0.1411 | 0.7679 |
| fmort_dev | -2.0150 | 0.0858 | rec_dev | -0.2295 | 0.5737 | fydev | 0.1112 | 0.7521 |
| fmort_dev | -2.2083 | 0.0815 | rec_dev | -0.4325 | 0.5799 | fydev | 0.1216 | 0.7563 |
| fmort_dev | -1.9151 | 0.0775 | rec_dev | -0.3189 | 0.6174 | fydev | 0.1579 | 0.7710 |
| fmort_dev | -1.5919 | 0.0739 | rec_dev | 0.7904 | 0.5522 | fydev | 0.1718 | 0.7784 |
| fmort_dev | -1.2944 | 0.0708 | rec_dev | 1.4376 | 0.3218 | fydev | 0.1480 | 0.7717 |
| fmort_dev | -1.6505 | 0.0679 | rec_dev | -0.2599 | 0.6317 | fydev | 0.0818 | 0.7508 |
| fmort_dev | -0.2930 | 0.0653 | rec_dev | -0.4568 | 0.5516 | fydev | -0.0053 | 0.7250 |
| fmort_dev | -0.9441 | 0.0630 | rec_dev | -0.1650 | 0.5578 | fydev | -0.0904 | 0.7013 |
| fmort_dev | -0.1232 | 0.0607 | rec_dev | 1.2847 | 0.1919 | fydev | -0.1569 | 0.6837 |
| fmort_dev | 0.9258 | 0.0590 | rec_dev | -0.4090 | 0.5447 | fydev | -0.2018 | 0.6723 |
| fmort_dev | 0.8274 | 0.0577 | rec_dev | -0.5722 | 0.4508 | fydev | -0.2265 | 0.6663 |
| fmort_dev | 0.6343 | 0.0566 | rec_dev | -0.6926 | 0.5004 | fydev | -0.2362 | 0.6639 |
| fmort_dev | 1.1272 | 0.0553 | rec_dev | 0.8432 | 0.2202 | fydev | -0.2320 | 0.6649 |
| fmort_dev | -0.0009 | 0.0542 | rec_dev | 0.0231 | 0.5212 | fydev | -0.2255 | 0.6666 |
| fmort_dev | 0.5330 | 0.0534 | rec_dev | 1.0273 | 0.2729 | fydev | -0.2172 | 0.6688 |
| fmort_dev | 0.8934 | 0.0529 | rec_dev | 1.0188 | 0.2981 | fydev | -0.2078 | 0.6714 |
| fmort_dev | 0.7665 | 0.0525 | rec_dev | 0.4811 | 0.4468 | fydev | -0.1997 | 0.6737 |
| fmort_dev | 1.0233 | 0.0524 | rec_dev | 0.4075 | 0.3713 | fydev | -0.1922 | 0.6759 |
| fmort_dev | 0.5593 | 0.0527 | rec_dev | -0.6017 | 0.5112 | fydev | -0.1858 | 0.6778 |
| fmort_dev | 0.7221 | 0.0533 | rec_dev | -0.4021 | 0.4209 | fydev | -0.1802 | 0.6795 |
| fmort_dev | 0.6381 | 0.0542 | rec_dev | -0.6009 | 0.5008 | fydev | -0.1737 | 0.6814 |
| fmort_dev | 0.4495 | 0.0553 | rec_dev | 0.2402 | 0.3275 | fydev | -0.1669 | 0.6834 |
| fmort_dev | 0.3545 | 0.0566 | rec_dev | 0.0834 | 0.4018 | fydev | -0.1602 | 0.6855 |
| fmort_dev | 0.3523 | 0.0581 | rec_dev | -0.1336 | 0.4788 | fydev | -0.1540 | 0.6874 |
| fmort_dev | 0.1810 | 0.0598 | rec_dev | 1.1964 | 0.1737 | fydev | -0.1478 | 0.6893 |
| fmort_dev | 0.1215 | 0.0619 | rec_dev | -0.1976 | 0.5048 | fydev | -0.1416 | 0.6913 |
| fmort_dev | 0.4620 | 0.0643 | rec_dev | -0.0965 | 0.4316 | fydev | -0.1357 | 0.69309 |
| fmort_dev | -0.0517 | 0.0669 | rec_dev | -0.0431 | 0.4017 | fydev | -0.1298 | 0.6949 |
| fmort_dev | -0.1511 | 0.0697 | rec_dev | 0.0916 | 0.3053 | fydev | -0.1243 | 0.6967 |
| fmort_dev | -0.3599 | 0.0725 | rec_dev | -0.7013 | 0.4759 | fydev | -0.4541 | 0.6115 |
| fmort_dev | -0.2528 | 0.0755 | rec_dev | -0.1500 | 0.3189 | q_srv | 1.0000 | 0.0010 |
| fmort_dev | 0.9493 | 0.0788 | rec_dev | -0.7352 | 0.4638 | mat_beta1 | -5.7428 | 0.6954 |
| fmort_dev | 0.4778 | 0.0825 | rec_dev | -0.4515 | 0.4110 | mat_beta2 | 0.7000 | 0.0094 |
| fmort_dev | 0.5298 | 0.0862 | | | | | | |

Table 23. Estimated time series of northern rockfish total biomass (t, age 3+), spawning biomass (t, age 3+), and recruitment (thousands, age 3).

| | Total Biomass (ages 3+) | | | | Spawner Biomass (ages 3+) | | | | Recruitment (age 3) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Assessment Year | | | | Assessment Year | | | | Assessment Year | | | |
| | 2023 | | 2021 | | 2023 | | 2021 | | 2023 | | 2021 | |
| Year | Est. | CV | Est. | CV | Est. | CV | Est. | CV | Est. | CV | Est. | CV |
| 1977 | 150,260 | 0.145 | 151,640 | 0.145 | 55,180 | 0.168 | 57,227 | 0.161 | 44,940 | 0.650 | 61,674 | 0.480 |
| 1978 | 154,830 | 0.142 | 156,490 | 0.143 | 58,078 | 0.167 | 59,577 | 0.161 | 39,799 | 0.653 | 46,013 | 0.562 |
| 1979 | 158,940 | 0.139 | 160,760 | 0.140 | 61,560 | 0.161 | 62,431 | 0.157 | 40,461 | 0.662 | 41,684 | 0.531 |
| 1980 | 165,360 | 0.135 | 166,870 | 0.136 | 65,594 | 0.152 | 65,979 | 0.151 | 47,224 | 0.683 | 41,530 | 0.536 |
| 1981 | 172,300 | 0.131 | 173,620 | 0.132 | 69,157 | 0.144 | 69,346 | 0.144 | 56,560 | 0.668 | 56,180 | 0.467 |
| 1982 | 179,160 | 0.126 | 180,600 | 0.127 | 72,348 | 0.137 | 72,615 | 0.139 | 48,240 | 0.663 | 53,475 | 0.443 |
| 1983 | 185,320 | 0.122 | 186,240 | 0.123 | 75,246 | 0.132 | 75,727 | 0.134 | 40,059 | 0.627 | 32,477 | 0.561 |
| 1984 | 190,990 | 0.118 | 193,660 | 0.119 | 78,063 | 0.127 | 78,770 | 0.129 | 35,893 | 0.582 | 69,321 | 0.332 |
| 1985 | 195,680 | 0.114 | 199,470 | 0.115 | 80,831 | 0.123 | 81,680 | 0.124 | 29,298 | 0.591 | 38,668 | 0.487 |
| 1986 | 200,010 | 0.110 | 204,510 | 0.111 | 83,593 | 0.118 | 84,520 | 0.119 | 32,823 | 0.630 | 32,575 | 0.533 |
| 1987 | 208,190 | 0.106 | 214,150 | 0.107 | 86,287 | 0.114 | 87,332 | 0.115 | 99,525 | 0.563 | 119,190 | 0.257 |
| 1988 | 223,450 | 0.102 | 225,180 | 0.103 | 88,875 | 0.110 | 90,111 | 0.112 | 190,110 | 0.324 | 118,350 | 0.274 |
| 1989 | 231,800 | 0.099 | 233,410 | 0.100 | 91,302 | 0.106 | 92,903 | 0.108 | 34,819 | 0.649 | 48,840 | 0.474 |
| 1990 | 239,310 | 0.096 | 242,000 | 0.096 | 93,786 | 0.104 | 95,823 | 0.106 | 28,595 | 0.566 | 57,894 | 0.347 |
| 1991 | 245,760 | 0.093 | 248,810 | 0.093 | 96,552 | 0.104 | 98,895 | 0.104 | 38,285 | 0.573 | 45,227 | 0.411 |
| 1992 | 260,070 | 0.090 | 259,530 | 0.090 | 100,320 | 0.104 | 102,610 | 0.103 | 163,160 | 0.199 | 113,820 | 0.199 |
| 1993 | 267,130 | 0.087 | 266,290 | 0.088 | 104,370 | 0.104 | 106,270 | 0.102 | 29,994 | 0.560 | 44,039 | 0.380 |
| 1994 | 270,310 | 0.086 | 270,150 | 0.086 | 107,920 | 0.102 | 109,250 | 0.100 | 25,477 | 0.463 | 48,987 | 0.310 |
| 1995 | 272,170 | 0.084 | 272,470 | 0.084 | 111,300 | 0.098 | 112,100 | 0.096 | 22,587 | 0.516 | 32,476 | 0.429 |
| 1996 | 278,710 | 0.082 | 278,040 | 0.083 | 114,230 | 0.094 | 114,590 | 0.093 | 104,930 | 0.227 | 94,115 | 0.194 |
| 1997 | 280,060 | 0.081 | 279,010 | 0.082 | 116,500 | 0.092 | 116,460 | 0.091 | 46,209 | 0.537 | 44,321 | 0.362 |
| 1998 | 289,970 | 0.079 | 287,720 | 0.080 | 119,720 | 0.089 | 119,310 | 0.089 | 126,130 | 0.281 | 119,010 | 0.188 |
| 1999 | 299,910 | 0.078 | 295,010 | 0.079 | 121,870 | 0.086 | 121,240 | 0.087 | 125,060 | 0.308 | 97,476 | 0.226 |
| 2000 | 306,420 | 0.077 | 300,500 | 0.078 | 123,260 | 0.085 | 122,550 | 0.086 | 73,049 | 0.457 | 78,842 | 0.248 |
| 2001 | 312,410 | 0.076 | 305,020 | 0.077 | 124,530 | 0.086 | 123,690 | 0.086 | 67,865 | 0.374 | 62,717 | 0.254 |
| 2002 | 314,190 | 0.075 | 306,180 | 0.077 | 126,210 | 0.087 | 125,010 | 0.087 | 24,737 | 0.523 | 30,402 | 0.377 |
| 2003 | 318,250 | 0.074 | 309,920 | 0.076 | 129,770 | 0.089 | 127,970 | 0.088 | 30,204 | 0.428 | 37,934 | 0.277 |
| 2004 | 320,930 | 0.074 | 311,940 | 0.076 | 133,990 | 0.089 | 131,400 | 0.088 | 24,756 | 0.512 | 21,560 | 0.403 |
| 2005 | 324,510 | 0.073 | 314,540 | 0.076 | 138,300 | 0.086 | 134,880 | 0.087 | 57,409 | 0.332 | 51,306 | 0.236 |
| 2006 | 328,320 | 0.073 | 317,910 | 0.076 | 142,440 | 0.083 | 138,320 | 0.085 | 49,079 | 0.408 | 52,793 | 0.251 |
| 2007 | 326,720 | 0.073 | 316,250 | 0.077 | 143,580 | 0.079 | 138,950 | 0.083 | 39,505 | 0.493 | 47,582 | 0.293 |
| 2008 | 332,790 | 0.073 | 319,230 | 0.077 | 144,250 | 0.078 | 139,290 | 0.082 | 149,370 | 0.177 | 111,100 | 0.171 |
| 2009 | 334,810 | 0.073 | 321,230 | 0.078 | 144,560 | 0.077 | 139,380 | 0.082 | 37,056 | 0.517 | 55,913 | 0.269 |
| 2010 | 336,900 | 0.074 | 323,200 | 0.079 | 144,630 | 0.078 | 139,250 | 0.083 | 40,996 | 0.436 | 49,133 | 0.264 |
| 2011 | 337,570 | 0.074 | 322,850 | 0.081 | 144,670 | 0.079 | 139,010 | 0.085 | 43,248 | 0.409 | 31,756 | 0.332 |
| 2012 | 339,560 | 0.075 | 324,060 | 0.082 | 145,670 | 0.081 | 139,660 | 0.088 | 49,482 | 0.311 | 46,372 | 0.245 |
| 2013 | 341,050 | 0.076 | 324,630 | 0.084 | 147,830 | 0.083 | 141,310 | 0.090 | 22,393 | 0.489 | 17,969 | 0.413 |
| 2014 | 343,230 | 0.078 | 325,040 | 0.086 | 150,370 | 0.084 | 143,310 | 0.092 | 38,864 | 0.325 | 23,259 | 0.360 |
| 2015 | 341,460 | 0.079 | 321,960 | 0.088 | 151,130 | 0.085 | 143,590 | 0.093 | 21,646 | 0.476 | 17,834 | 0.460 |
| 2016 | 335,100 | 0.082 | 314,450 | 0.091 | 150,060 | 0.086 | 142,090 | 0.095 | 28,746 | 0.421 | 27,581 | 0.438 |
| 2017 | 330,860 | 0.084 | 308,400 | 0.095 | 149,120 | 0.088 | 140,510 | 0.097 | 36,252 | 0.437 | 29,141 | 0.529 |
| 2018 | 328,830 | 0.087 | 304,580 | 0.098 | 148,630 | 0.090 | 139,270 | 0.100 | 36,464 | 0.471 | 31,010 | 0.563 |
| 2019 | 325,720 | 0.090 | 299,120 | 0.101 | 146,870 | 0.093 | 135,660 | 0.104 | 39,519 | 0.494 | | |
| 2020 | 318,910 | 0.094 | 291,690 | 0.105 | 143,850 | 0.097 | 130,750 | 0.109 | 22,762 | 0.589 | | |
| 2021 | 314,780 | 0.098 | 285,730 | 0.108 | 141,160 | 0.101 | 125,930 | 0.114 | | | | |
| 2022 | 313,630 | 0.101 | 279,584 | | 139,090 | 0.105 | 121,126 | | | | | |
| 2023 | 308,010 | 0.104 | | | 132,760 | 0.111 | | | | | | |
| 2024 | 297,189 | | | | 128,229 | | | | | | | |
| Mean recruitment of post-1976 year classes | | | | | | | | | 55,082 | | 54,671 | |

Table 24. Estimated numbers at age for BSAI northern rockfish (millions).

| | Age | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| 1977 | 44.94 | 23.36 | 26.00 | 27.22 | 144.05 | 21.74 | 19.06 | 17.13 | 15.78 | 15.13 | 14.89 | 14.33 | 13.28 | 11.80 | 10.26 | 8.94 | 7.94 | 7.21 | 6.67 | 6.27 |
| 1978 | 39.80 | 42.64 | 22.16 | 24.66 | 25.79 | 136.27 | 20.51 | 17.91 | 16.03 | 14.72 | 14.08 | 13.84 | 13.31 | 12.33 | 10.95 | 9.53 | 8.30 | 7.37 | 6.69 | 6.19 |
| 1979 | 40.46 | 37.76 | 40.45 | 21.01 | 23.36 | 24.39 | 128.48 | 19.25 | 16.74 | 14.93 | 13.67 | 13.06 | 12.83 | 12.34 | 11.43 | 10.15 | 8.83 | 7.69 | 6.83 | 6.20 |
| 1980 | 47.22 | 38.40 | 35.84 | 38.38 | 19.94 | 22.16 | 23.12 | 121.72 | 18.23 | 15.84 | 14.12 | 12.93 | 12.35 | 12.13 | 11.66 | 10.81 | 9.60 | 8.35 | 7.27 | 6.46 |
| 1981 | 56.56 | 44.81 | 36.44 | 34.00 | 36.42 | 18.91 | 21.01 | 21.91 | 115.25 | 17.25 | 14.98 | 13.35 | 12.23 | 11.68 | 11.47 | 11.03 | 10.22 | 9.07 | 7.89 | 6.88 |
| 1982 | 48.24 | 53.68 | 42.53 | 34.58 | 32.27 | 34.56 | 17.94 | 19.93 | 20.78 | 109.31 | 16.36 | 14.21 | 12.66 | 11.59 | 11.08 | 10.88 | 10.46 | 9.69 | 8.61 | 7.48 |
| 1983 | 40.06 | 45.78 | 50.94 | 40.36 | 32.81 | 30.62 | 32.79 | 17.02 | 18.90 | 19.70 | 103.62 | 15.51 | 13.47 | 12.00 | 10.99 | 10.50 | 10.31 | 9.92 | 9.19 | 8.16 |
| 1984 | 35.89 | 38.02 | 43.45 | 48.34 | 38.30 | 31.14 | 29.05 | 31.11 | 16.15 | 17.93 | 18.69 | 98.30 | 14.71 | 12.77 | 11.39 | 10.42 | 9.96 | 9.78 | 9.41 | 8.71 |
| 1985 | 29.30 | 34.06 | 36.08 | 41.23 | 45.87 | 36.34 | 29.54 | 27.56 | 29.50 | 15.31 | 17.00 | 17.72 | 93.19 | 13.95 | 12.11 | 10.79 | 9.88 | 9.44 | 9.28 | 8.92 |
| 1986 | 32.82 | 27.80 | 32.33 | 34.24 | 39.12 | 43.53 | 34.48 | 28.02 | 26.14 | 27.98 | 14.52 | 16.12 | 16.80 | 88.37 | 13.22 | 11.48 | 10.24 | 9.37 | 8.95 | 8.79 |
| 1987 | 99.52 | 31.15 | 26.39 | 30.68 | 32.49 | 37.12 | 41.30 | 32.71 | 26.58 | 24.78 | 26.52 | 13.76 | 15.28 | 15.93 | 83.76 | 12.53 | 10.89 | 9.70 | 8.88 | 8.49 |
| 1988 | 190.11 | 94.45 | 29.56 | 25.04 | 29.11 | 30.83 | 35.22 | 39.16 | 31.01 | 25.19 | 23.49 | 25.13 | 13.04 | 14.48 | 15.09 | 79.37 | 11.88 | 10.31 | 9.19 | 8.42 |
| 1989 | 34.82 | 180.41 | 89.63 | 28.05 | 23.76 | 27.62 | 29.24 | 33.39 | 37.11 | 29.38 | 23.86 | 22.24 | 23.80 | 12.35 | 13.71 | 14.29 | 75.16 | 11.25 | 9.77 | 8.71 |
| 1990 | 28.60 | 33.04 | 171.21 | 85.06 | 26.62 | 22.54 | 26.20 | 27.73 | 31.65 | 35.18 | 27.84 | 22.61 | 21.08 | 22.56 | 11.70 | 12.99 | 13.54 | 71.22 | 10.66 | 9.26 |
| 1991 | 38.29 | 27.14 | 31.36 | 162.45 | 80.69 | 25.24 | 21.36 | 24.80 | 26.21 | 29.90 | 33.21 | 26.27 | 21.34 | 19.89 | 21.28 | 11.04 | 12.26 | 12.78 | 67.20 | 10.06 |
| 1992 | 163.16 | 36.33 | 25.75 | 29.75 | 154.13 | 76.54 | 23.93 | 20.24 | 23.49 | 24.82 | 28.30 | 31.43 | 24.86 | 20.19 | 18.82 | 20.14 | 10.45 | 11.60 | 12.09 | 63.58 |
| 1993 | 29.99 | 154.84 | 34.48 | 24.43 | 28.22 | 146.12 | 72.50 | 22.64 | 19.12 | 22.17 | 23.41 | 26.68 | 29.62 | 23.43 | 19.03 | 17.74 | 18.98 | 9.85 | 10.93 | 11.39 |
| 1994 | 25.48 | 28.46 | 146.90 | 32.70 | 23.15 | 26.71 | 137.92 | 68.19 | 21.22 | 17.87 | 20.67 | 21.80 | 24.84 | 27.57 | 21.80 | 17.70 | 16.50 | 17.66 | 9.16 | 10.17 |
| 1995 | 22.59 | 24.18 | 27.00 | 139.32 | 30.99 | 21.92 | 25.22 | 129.83 | 63.97 | 19.85 | 16.68 | 19.28 | 20.33 | 23.16 | 25.70 | 20.33 | 16.50 | 15.38 | 16.46 | 8.54 |
| 1996 | 104.93 | 21.43 | 22.94 | 25.61 | 132.07 | 29.34 | 20.71 | 23.77 | 122.05 | 60.00 | 18.59 | 15.61 | 18.04 | 19.01 | 21.65 | 24.03 | 19.01 | 15.43 | 14.38 | 15.39 |
| 1997 | 46.21 | 99.56 | 20.33 | 21.75 | 24.26 | 124.90 | 27.66 | 19.44 | 22.21 | 113.61 | 55.71 | 17.24 | 14.47 | 16.71 | 17.61 | 20.06 | 22.26 | 17.61 | 14.29 | 13.32 |
| 1998 | 126.13 | 43.85 | 94.47 | 19.29 | 20.63 | 23.00 | 118.27 | 26.16 | 18.36 | 20.95 | 107.06 | 52.48 | 16.24 | 13.63 | 15.74 | 16.59 | 18.89 | 20.96 | 16.58 | 13.46 |
| 1999 | 125.06 | 119.69 | 41.61 | 89.61 | 18.29 | 19.54 | 21.75 | 111.57 | 24.61 | 17.24 | 19.64 | 100.32 | 49.16 | 15.21 | 12.76 | 14.74 | 15.53 | 17.69 | 19.63 | 15.53 |
| 2000 | 73.05 | 118.67 | 113.55 | 39.46 | 84.92 | 17.31 | 18.45 | 20.46 | 104.58 | 23.01 | 16.08 | 18.31 | 93.44 | 45.78 | 14.16 | 11.88 | 13.72 | 14.46 | 16.47 | 18.28 |
| 2001 | 67.87 | 69.32 | 112.59 | 107.70 | 37.40 | 80.40 | 16.35 | 17.37 | 19.21 | 97.92 | 21.50 | 15.02 | 17.09 | 87.21 | 42.72 | 13.21 | 11.09 | 12.80 | 13.49 | 15.37 |
| 2002 | 24.74 | 64.39 | 65.76 | 106.77 | 102.05 | 35.38 | 75.84 | 15.36 | 16.26 | 17.91 | 91.13 | 19.99 | 13.95 | 15.87 | 80.99 | 39.67 | 12.27 | 10.30 | 11.89 | 12.53 |
| 2003 | 30.20 | 23.47 | 61.10 | 62.38 | 101.22 | 96.65 | 33.45 | 71.53 | 14.45 | 15.26 | 16.79 | 85.36 | 18.72 | 13.06 | 14.86 | 75.82 | 37.14 | 11.48 | 9.64 | 11.13 |
| 2004 | 24.76 | 28.66 | 22.27 | 57.95 | 59.13 | 95.83 | 91.32 | 31.51 | 67.18 | 13.54 | 14.27 | 15.69 | 79.75 | 17.48 | 12.20 | 13.88 | 70.80 | 34.68 | 10.72 | 9.00 |
| 2005 | 57.41 | 23.49 | 27.19 | 21.12 | 54.94 | 55.99 | 90.58 | 86.08 | 29.62 | 63.00 | 12.68 | 13.36 | 14.68 | 74.58 | 16.35 | 11.41 | 12.98 | 66.20 | 32.43 | 10.03 |
| 2006 | 49.08 | 54.48 | 22.29 | 25.80 | 20.03 | 52.04 | 52.96 | 85.48 | 81.05 | 27.84 | 59.14 | 11.89 | 12.52 | 13.76 | 69.92 | 15.33 | 10.69 | 12.16 | 62.06 | 30.40 |
| 2007 | 39.50 | 46.57 | 51.69 | 21.14 | 24.46 | 18.98 | 49.24 | 50.00 | 80.54 | 76.23 | 26.16 | 55.53 | 11.17 | 11.76 | 12.92 | 65.62 | 14.38 | 10.04 | 11.42 | 58.24 |
| 2008 | 149.37 | 37.49 | 44.19 | 49.04 | 20.05 | 23.18 | 17.95 | 46.49 | 47.11 | 75.76 | 71.63 | 24.56 | 52.13 | 10.48 | 11.03 | 12.12 | 61.58 | 13.50 | 9.42 | 10.71 |
| 2009 | 37.06 | 141.75 | 35.57 | 41.92 | 46.50 | 19.00 | 21.94 | 16.97 | 43.86 | 44.38 | 71.29 | 67.37 | 23.10 | 49.01 | 9.85 | 10.37 | 11.40 | 57.90 | 12.69 | 8.86 |
| 2010 | 41.00 | 35.16 | 134.50 | 33.75 | 39.76 | 44.08 | 17.99 | 20.74 | 16.01 | 41.33 | 41.78 | 67.09 | 63.39 | 21.73 | 46.11 | 9.27 | 9.76 | 10.72 | 54.46 | 11.94 |
| 2011 | 43.25 | 38.90 | 33.37 | 127.59 | 32.00 | 37.66 | 41.69 | 16.98 | 19.52 | 15.04 | 38.78 | 39.19 | 62.90 | 59.42 | 20.37 | 43.22 | 8.69 | 9.15 | 10.05 | 51.04 |
| 2012 | 49.48 | 41.04 | 36.91 | 31.66 | 121.02 | 30.33 | 35.67 | 39.43 | 16.03 | 18.42 | 14.18 | 36.55 | 36.92 | 59.26 | 55.97 | 19.18 | 40.71 | 8.18 | 8.61 | 9.47 |
| 2013 | 22.39 | 46.96 | 38.94 | 35.02 | 30.03 | 114.74 | 28.73 | 33.75 | 37.26 | 15.13 | 17.37 | 13.37 | 34.46 | 34.80 | 55.86 | 52.76 | 18.08 | 38.37 | 7.71 | 8.12 |
| 2014 | 38.86 | 21.25 | 44.56 | 36.95 | 33.23 | 28.47 | 108.72 | 27.20 | 31.92 | 35.20 | 14.29 | 16.40 | 12.62 | 32.52 | 32.85 | 52.73 | 49.80 | 17.07 | 36.22 | 7.28 |
| 2015 | 21.65 | 36.88 | 20.16 | 42.28 | 35.05 | 31.50 | 26.98 | 102.90 | 25.71 | 30.14 | 33.23 | 13.49 | 15.47 | 11.91 | 30.68 | 30.99 | 49.73 | 46.98 | 16.10 | 34.16 |
| 2016 | 28.75 | 20.54 | 34.99 | 19.12 | 40.06 | 33.17 | 29.73 | 25.37 | 96.38 | 24.01 | 28.09 | 30.93 | 12.55 | 14.39 | 11.08 | 28.53 | 28.82 | 46.25 | 43.69 | 14.97 |
| 2017 | 36.25 | 27.28 | 19.49 | 33.19 | 18.13 | 37.95 | 31.37 | 28.05 | 23.88 | 90.55 | 22.53 | 26.34 | 28.99 | 11.76 | 13.49 | 10.38 | 26.74 | 27.01 | 43.34 | 40.94 |
| 2018 | 36.46 | 34.40 | 25.88 | 18.49 | 31.47 | 17.17 | 35.88 | 29.59 | 26.40 | 22.42 | 84.92 | 21.11 | 24.67 | 27.16 | 11.01 | 12.63 | 9.72 | 25.04 | 25.29 | 40.59 |
| 2019 | 39.52 | 34.60 | 32.64 | 24.55 | 17.52 | 29.79 | 16.22 | 33.80 | 27.78 | 24.72 | 20.97 | 79.33 | 19.72 | 23.04 | 25.35 | 10.28 | 11.79 | 9.07 | 23.37 | 23.61 |
| 2020 | 22.76 | 37.50 | 32.82 | 30.94 | 23.25 | 16.56 | 28.06 | 15.21 | 31.52 | 25.80 | 22.90 | 19.39 | 73.31 | 18.21 | 21.28 | 23.41 | 9.50 | 10.89 | 8.38 | 21.59 |
| 2021 | 59.82 | 21.60 | 35.57 | 31.12 | 29.31 | 21.98 | 15.61 | 26.32 | 14.19 | 29.29 | 23.91 | 21.19 | 17.93 | 67.78 | 16.84 | 19.67 | 21.64 | 8.78 | 10.07 | 7.75 |
| 2022 | 59.82 | 56.76 | 20.49 | 33.73 | 29.49 | 27.73 | 20.75 | 14.68 | 24.66 | 13.25 | 27.30 | 22.27 | 19.72 | 16.69 | 63.07 | 15.66 | 18.30 | 20.13 | 8.17 | 9.36 |
| 2023 | 59.82 | 56.76 | 53.84 | 19.43 | 31.95 | 27.88 | 26.13 | 19.46 | 13.70 | 22.92 | 12.29 | 25.28 | 20.60 | 18.24 | 15.43 | 58.31 | 14.48 | 16.92 | 18.62 | 7.55 |

Table 24 (continued). Estimated numbers at age for BSAI northern rockfish (millions).

| | Age | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40+ |
| 1977 | 6.67 | 6.27 | 5.98 | 5.71 | 5.46 | 5.23 | 5.01 | 4.79 | 4.57 | 4.36 | 4.17 | 3.98 | 3.80 | 3.63 | 3.47 | 3.31 | 3.16 | 3.02 | 2.88 | 10.39 |
| 1978 | 6.69 | 6.19 | 5.82 | 5.55 | 5.30 | 5.07 | 4.86 | 4.65 | 4.44 | 4.24 | 4.05 | 3.87 | 3.70 | 3.53 | 3.37 | 3.22 | 3.08 | 2.94 | 2.80 | 12.32 |
| 1979 | 6.83 | 6.20 | 5.74 | 5.39 | 5.14 | 4.91 | 4.70 | 4.50 | 4.31 | 4.12 | 3.93 | 3.75 | 3.59 | 3.43 | 3.27 | 3.13 | 2.98 | 2.85 | 2.72 | 14.02 |
| 1980 | 7.27 | 6.46 | 5.86 | 5.43 | 5.10 | 4.86 | 4.64 | 4.44 | 4.26 | 4.07 | 3.89 | 3.72 | 3.55 | 3.39 | 3.24 | 3.09 | 2.95 | 2.82 | 2.69 | 15.82 |
| 1981 | 7.89 | 6.88 | 6.11 | 5.54 | 5.13 | 4.82 | 4.60 | 4.39 | 4.20 | 4.02 | 3.85 | 3.68 | 3.52 | 3.36 | 3.21 | 3.06 | 2.93 | 2.79 | 2.67 | 17.51 |
| 1982 | 8.61 | 7.48 | 6.52 | 5.79 | 5.26 | 4.87 | 4.57 | 4.36 | 4.16 | 3.98 | 3.82 | 3.65 | 3.49 | 3.33 | 3.18 | 3.04 | 2.90 | 2.78 | 2.65 | 19.14 |
| 1983 | 9.19 | 8.16 | 7.09 | 6.18 | 5.49 | 4.98 | 4.61 | 4.33 | 4.13 | 3.95 | 3.78 | 3.62 | 3.46 | 3.31 | 3.16 | 3.02 | 2.88 | 2.75 | 2.63 | 20.65 |
| 1984 | 9.41 | 8.71 | 7.74 | 6.73 | 5.87 | 5.21 | 4.73 | 4.38 | 4.11 | 3.92 | 3.74 | 3.58 | 3.43 | 3.28 | 3.14 | 3.00 | 2.86 | 2.73 | 2.61 | 22.08 |
| 1985 | 9.28 | 8.92 | 8.26 | 7.34 | 6.38 | 5.56 | 4.94 | 4.48 | 4.15 | 3.90 | 3.72 | 3.55 | 3.40 | 3.25 | 3.11 | 2.98 | 2.84 | 2.71 | 2.59 | 23.41 |
| 1986 | 8.95 | 8.79 | 8.46 | 7.83 | 6.96 | 6.05 | 5.27 | 4.68 | 4.25 | 3.93 | 3.70 | 3.52 | 3.37 | 3.22 | 3.08 | 2.95 | 2.82 | 2.70 | 2.57 | 24.66 |
| 1987 | 8.88 | 8.49 | 8.34 | 8.01 | 7.42 | 6.59 | 5.73 | 5.00 | 4.44 | 4.03 | 3.73 | 3.50 | 3.34 | 3.19 | 3.05 | 2.92 | 2.80 | 2.67 | 2.55 | 25.81 |
| 1988 | 9.19 | 8.42 | 8.04 | 7.90 | 7.59 | 7.03 | 6.25 | 5.43 | 4.74 | 4.21 | 3.82 | 3.53 | 3.32 | 3.16 | 3.02 | 2.89 | 2.77 | 2.65 | 2.53 | 26.88 |
| 1989 | 9.77 | 8.71 | 7.97 | 7.62 | 7.48 | 7.19 | 6.66 | 5.92 | 5.15 | 4.48 | 3.98 | 3.61 | 3.35 | 3.14 | 3.00 | 2.86 | 2.74 | 2.62 | 2.51 | 27.85 |
| 1990 | 10.66 | 9.26 | 8.25 | 7.55 | 7.22 | 7.09 | 6.81 | 6.31 | 5.61 | 4.88 | 4.25 | 3.77 | 3.42 | 3.17 | 2.98 | 2.84 | 2.71 | 2.60 | 2.49 | 28.77 |
| 1991 | 67.20 | 10.06 | 8.73 | 7.78 | 7.13 | 6.81 | 6.69 | 6.43 | 5.96 | 5.29 | 4.60 | 4.01 | 3.56 | 3.23 | 2.99 | 2.81 | 2.68 | 2.56 | 2.45 | 29.49 |
| 1992 | 12.09 | 63.58 | 9.51 | 8.26 | 7.36 | 6.74 | 6.44 | 6.33 | 6.08 | 5.64 | 5.00 | 4.35 | 3.79 | 3.37 | 3.06 | 2.83 | 2.66 | 2.53 | 2.42 | 30.22 |
| 1993 | 10.93 | 11.39 | 59.92 | 8.97 | 7.79 | 6.94 | 6.35 | 6.07 | 5.96 | 5.73 | 5.31 | 4.72 | 4.10 | 3.58 | 3.17 | 2.88 | 2.67 | 2.51 | 2.39 | 30.76 |
| 1994 | 9.16 | 10.17 | 10.60 | 55.75 | 8.34 | 7.24 | 6.46 | 5.91 | 5.65 | 5.55 | 5.33 | 4.94 | 4.39 | 3.82 | 3.33 | 2.95 | 2.68 | 2.48 | 2.33 | 30.84 |
| 1995 | 16.46 | 8.54 | 9.48 | 9.88 | 51.97 | 7.78 | 6.75 | 6.02 | 5.51 | 5.27 | 5.17 | 4.97 | 4.61 | 4.09 | 3.56 | 3.10 | 2.75 | 2.50 | 2.31 | 30.92 |
| 1996 | 14.38 | 15.39 | 7.98 | 8.86 | 9.24 | 48.59 | 7.27 | 6.31 | 5.63 | 5.15 | 4.92 | 4.84 | 4.65 | 4.31 | 3.83 | 3.33 | 2.90 | 2.57 | 2.34 | 31.08 |
| 1997 | 14.29 | 13.32 | 14.26 | 7.40 | 8.21 | 8.56 | 45.02 | 6.74 | 5.85 | 5.21 | 4.77 | 4.56 | 4.48 | 4.31 | 3.99 | 3.54 | 3.08 | 2.69 | 2.39 | 30.95 |
| 1998 | 16.58 | 13.46 | 12.55 | 13.42 | 6.96 | 7.73 | 8.06 | 42.39 | 6.34 | 5.51 | 4.91 | 4.49 | 4.29 | 4.22 | 4.06 | 3.76 | 3.34 | 2.90 | 2.53 | 31.39 |
| 1999 | 19.63 | 15.53 | 12.60 | 11.75 | 12.57 | 6.52 | 7.24 | 7.55 | 39.69 | 5.94 | 5.16 | 4.60 | 4.21 | 4.02 | 3.95 | 3.80 | 3.52 | 3.12 | 2.72 | 31.77 |
| 2000 | 16.47 | 18.28 | 14.45 | 11.73 | 10.94 | 11.70 | 6.07 | 6.74 | 7.03 | 36.95 | 5.53 | 4.80 | 4.28 | 3.92 | 3.74 | 3.68 | 3.54 | 3.28 | 2.91 | 32.10 |
| 2001 | 13.49 | 15.37 | 17.06 | 13.49 | 10.95 | 10.21 | 10.92 | 5.67 | 6.29 | 6.56 | 34.48 | 5.16 | 4.48 | 3.99 | 3.66 | 3.49 | 3.43 | 3.30 | 3.06 | 32.67 |
| 2002 | 11.89 | 12.53 | 14.27 | 15.84 | 12.52 | 10.17 | 9.48 | 10.14 | 5.26 | 5.84 | 6.09 | 32.02 | 4.79 | 4.16 | 3.71 | 3.40 | 3.24 | 3.19 | 3.06 | 33.18 |
| 2003 | 9.64 | 11.13 | 11.73 | 13.36 | 14.82 | 11.72 | 9.52 | 8.87 | 9.49 | 4.93 | 5.47 | 5.70 | 29.97 | 4.49 | 3.90 | 3.47 | 3.18 | 3.04 | 2.98 | 33.92 |
| 2004 | 10.72 | 9.00 | 10.39 | 10.95 | 12.47 | 13.84 | 10.95 | 8.89 | 8.29 | 8.87 | 4.60 | 5.11 | 5.32 | 27.99 | 4.19 | 3.64 | 3.24 | 2.97 | 2.84 | 34.47 |
| 2005 | 32.43 | 10.03 | 8.42 | 9.72 | 10.24 | 11.66 | 12.94 | 10.24 | 8.31 | 7.75 | 8.29 | 4.30 | 4.77 | 4.98 | 26.17 | 3.92 | 3.40 | 3.03 | 2.78 | 34.88 |
| 2006 | 62.06 | 30.40 | 9.40 | 7.89 | 9.11 | 9.60 | 10.93 | 12.13 | 9.60 | 7.79 | 7.26 | 7.77 | 4.03 | 4.48 | 4.67 | 24.53 | 3.67 | 3.19 | 2.84 | 35.30 |
| 2007 | 11.42 | 58.24 | 28.53 | 8.82 | 7.40 | 8.55 | 9.01 | 10.26 | 11.39 | 9.01 | 7.31 | 6.82 | 7.29 | 3.78 | 4.20 | 4.38 | 23.03 | 3.45 | 2.99 | 35.79 |
| 2008 | 9.42 | 10.71 | 54.66 | 26.77 | 8.28 | 6.95 | 8.02 | 8.46 | 9.63 | 10.69 | 8.45 | 6.86 | 6.40 | 6.84 | 3.55 | 3.94 | 4.11 | 21.61 | 3.23 | 36.40 |
| 2009 | 12.69 | 8.86 | 10.07 | 51.39 | 25.17 | 7.78 | 6.53 | 7.54 | 7.95 | 9.05 | 10.05 | 7.95 | 6.45 | 6.01 | 6.43 | 3.34 | 3.71 | 3.86 | 20.32 | 37.26 |
| 2010 | 54.46 | 11.94 | 8.33 | 9.47 | 48.34 | 23.68 | 7.32 | 6.14 | 7.10 | 7.48 | 8.52 | 9.45 | 7.47 | 6.07 | 5.66 | 6.05 | 3.14 | 3.49 | 3.63 | 54.16 |
| 2011 | 10.05 | 51.04 | 11.19 | 7.81 | 8.88 | 45.31 | 22.19 | 6.86 | 5.76 | 6.65 | 7.01 | 7.98 | 8.86 | 7.01 | 5.69 | 5.30 | 5.67 | 2.94 | 3.27 | 54.17 |
| 2012 | 8.61 | 9.47 | 48.08 | 10.54 | 7.35 | 8.37 | 42.68 | 20.91 | 6.46 | 5.43 | 6.26 | 6.60 | 7.52 | 8.34 | 6.60 | 5.36 | 4.99 | 5.34 | 2.77 | 54.11 |
| 2013 | 7.71 | 8.12 | 8.92 | 45.33 | 9.94 | 6.93 | 7.89 | 40.23 | 19.71 | 6.09 | 5.11 | 5.91 | 6.22 | 7.09 | 7.87 | 6.22 | 5.05 | 4.71 | 5.04 | 53.62 |
| 2014 | 36.22 | 7.28 | 7.66 | 8.42 | 42.78 | 9.38 | 6.54 | 7.44 | 37.97 | 18.60 | 5.75 | 4.83 | 5.57 | 5.87 | 6.69 | 7.42 | 5.87 | 4.77 | 4.44 | 55.36 |
| 2015 | 16.10 | 34.16 | 6.87 | 7.23 | 7.94 | 40.35 | 8.85 | 6.17 | 7.02 | 35.82 | 17.54 | 5.43 | 4.55 | 5.26 | 5.54 | 6.31 | 7.00 | 5.54 | 4.50 | 56.41 |
| 2016 | 43.69 | 14.97 | 31.77 | 6.39 | 6.72 | 7.39 | 37.53 | 8.23 | 5.74 | 6.53 | 33.31 | 16.32 | 5.05 | 4.23 | 4.89 | 5.15 | 5.87 | 6.51 | 5.15 | 56.64 |
| 2017 | 43.34 | 40.94 | 14.03 | 29.77 | 5.99 | 6.30 | 6.92 | 35.17 | 7.71 | 5.38 | 6.12 | 31.22 | 15.29 | 4.73 | 3.97 | 4.58 | 4.83 | 5.50 | 6.10 | 57.91 |
| 2018 | 25.29 | 40.59 | 38.34 | 13.14 | 27.88 | 5.60 | 5.90 | 6.48 | 32.93 | 7.22 | 5.04 | 5.73 | 29.23 | 14.32 | 4.43 | 3.72 | 4.29 | 4.52 | 5.15 | 59.94 |
| 2019 | 23.37 | 23.61 | 37.89 | 35.79 | 12.27 | 26.03 | 5.23 | 5.51 | 6.05 | 30.74 | 6.74 | 4.70 | 5.35 | 27.29 | 13.37 | 4.13 | 3.47 | 4.01 | 4.22 | 60.76 |
| 2020 | 8.38 | 21.59 | 21.80 | 34.99 | 33.05 | 11.33 | 24.04 | 4.83 | 5.09 | 5.59 | 28.39 | 6.22 | 4.34 | 4.94 | 25.20 | 12.34 | 3.82 | 3.20 | 3.70 | 60.02 |
| 2021 | 10.07 | 7.75 | 19.95 | 20.15 | 32.35 | 30.55 | 10.47 | 22.22 | 4.47 | 4.70 | 5.17 | 26.24 | 5.75 | 4.01 | 4.57 | 23.29 | 11.41 | 3.53 | 2.96 | 58.89 |
| 2022 | 8.17 | 9.36 | 7.21 | 18.56 | 18.75 | 30.09 | 28.42 | 9.74 | 20.67 | 4.16 | 4.37 | 4.81 | 24.41 | 5.35 | 3.73 | 4.25 | 21.67 | 10.61 | 3.28 | 57.54 |
| 2023 | 18.62 | 7.55 | 8.66 | 6.66 | 17.16 | 17.33 | 27.82 | 26.28 | 9.01 | 19.11 | 3.84 | 4.04 | 4.44 | 22.57 | 4.95 | 3.45 | 3.93 | 20.04 | 9.81 | 56.24 |

Table 25. Projections of BSAI northern rockfish catch (t), spawning biomass (t), and fishing mortality rate for each of the several scenarios. The values of $B_{40\%}$ and $B_{35\%}$ are 74,907 t and 65,544 t, respectively.

| **Catch** | *Scenario 1* | *Scenario 2* | *Scenario 3* | *Scenario 4* | *Scenario 5* | *Scenario 6* | *Scenario 7* |
|---|---|---|---|---|---|---|---|
| 2023 | 9,998 | 9,998 | 9,998 | 9,998 | 9,998 | 9,998 | 9,998 |
| 2024 | 19,274 | 19,274 | 4,528 | 6,555 | 0 | 23,556 | 19,274 |
| 2025 | 18,004 | 18,004 | 4,448 | 6,397 | 0 | 21,674 | 18,004 |
| 2026 | 16,912 | 16,912 | 4,385 | 6,265 | 0 | 20,068 | 20,672 |
| 2027 | 16,013 | 16,013 | 4,346 | 6,170 | 0 | 18,748 | 19,286 |
| 2028 | 15,305 | 15,305 | 4,332 | 6,115 | 0 | 17,701 | 18,180 |
| 2029 | 14,754 | 14,754 | 4,339 | 6,093 | 0 | 16,880 | 17,304 |
| 2030 | 14,311 | 14,311 | 4,359 | 6,090 | 0 | 16,215 | 16,590 |
| 2031 | 13,938 | 13,938 | 4,384 | 6,097 | 0 | 15,657 | 15,987 |
| 2032 | 13,616 | 13,616 | 4,411 | 6,109 | 0 | 15,177 | 15,468 |
| 2033 | 13,335 | 13,335 | 4,439 | 6,122 | 0 | 14,730 | 15,005 |
| 2034 | 13,087 | 13,087 | 4,466 | 6,137 | 0 | 14,278 | 14,547 |
| 2035 | 12,862 | 12,862 | 4,493 | 6,151 | 0 | 13,857 | 14,105 |
| 2036 | 12,653 | 12,653 | 4,517 | 6,164 | 0 | 13,476 | 13,699 |
| **Sp. Biomass** | *Scenario 1* | *Scenario 2* | *Scenario 3* | *Scenario 4* | *Scenario 5* | *Scenario 6* | *Scenario 7* |
| 2023 | 132,760 | 132,760 | 132,760 | 132,760 | 132,760 | 132,760 | 132,760 |
| 2024 | 127,029 | 127,029 | 128,662 | 128,441 | 129,151 | 126,543 | 127,029 |
| 2025 | 119,057 | 119,057 | 126,724 | 125,663 | 129,100 | 116,851 | 119,057 |
| 2026 | 112,308 | 112,308 | 125,330 | 123,488 | 129,501 | 108,687 | 111,886 |
| 2027 | 106,800 | 106,800 | 124,570 | 122,003 | 130,450 | 102,019 | 104,873 |
| 2028 | 102,388 | 102,388 | 124,388 | 121,143 | 131,900 | 96,662 | 99,198 |
| 2029 | 98,827 | 98,827 | 124,625 | 120,743 | 133,706 | 92,323 | 94,570 |
| 2030 | 95,861 | 95,861 | 125,093 | 120,610 | 135,690 | 88,716 | 90,701 |
| 2031 | 93,336 | 93,336 | 125,690 | 120,637 | 137,756 | 85,661 | 87,410 |
| 2032 | 91,155 | 91,155 | 126,354 | 120,759 | 139,842 | 83,042 | 84,580 |
| 2033 | 89,260 | 89,260 | 127,053 | 120,945 | 141,921 | 80,792 | 82,139 |
| 2034 | 87,588 | 87,588 | 127,747 | 121,150 | 143,949 | 78,852 | 80,022 |
| 2035 | 86,105 | 86,105 | 128,423 | 121,364 | 145,916 | 77,194 | 78,198 |
| 2036 | 84,785 | 84,785 | 129,068 | 121,572 | 147,809 | 75,786 | 76,639 |
| **F** | *Scenario 1* | *Scenario 2* | *Scenario 3* | *Scenario 4* | *Scenario 5* | *Scenario 6* | *Scenario 7* |
| 2023 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 |
| 2024 | 0.070 | 0.070 | 0.016 | 0.023 | 0.000 | 0.086 | 0.070 |
| 2025 | 0.070 | 0.070 | 0.016 | 0.023 | 0.000 | 0.086 | 0.070 |
| 2026 | 0.070 | 0.070 | 0.016 | 0.023 | 0.000 | 0.086 | 0.086 |
| 2027 | 0.070 | 0.070 | 0.016 | 0.023 | 0.000 | 0.086 | 0.086 |
| 2028 | 0.070 | 0.070 | 0.016 | 0.023 | 0.000 | 0.086 | 0.086 |
| 2029 | 0.070 | 0.070 | 0.016 | 0.023 | 0.000 | 0.086 | 0.086 |
| 2030 | 0.070 | 0.070 | 0.016 | 0.023 | 0.000 | 0.086 | 0.086 |
| 2031 | 0.070 | 0.070 | 0.016 | 0.023 | 0.000 | 0.086 | 0.086 |
| 2032 | 0.070 | 0.070 | 0.016 | 0.023 | 0.000 | 0.086 | 0.086 |
| 2033 | 0.070 | 0.070 | 0.016 | 0.023 | 0.000 | 0.086 | 0.086 |
| 2034 | 0.070 | 0.070 | 0.016 | 0.023 | 0.000 | 0.085 | 0.085 |
| 2035 | 0.070 | 0.070 | 0.016 | 0.023 | 0.000 | 0.084 | 0.085 |
| 2036 | 0.070 | 0.070 | 0.016 | 0.023 | 0.000 | 0.083 | 0.084 |

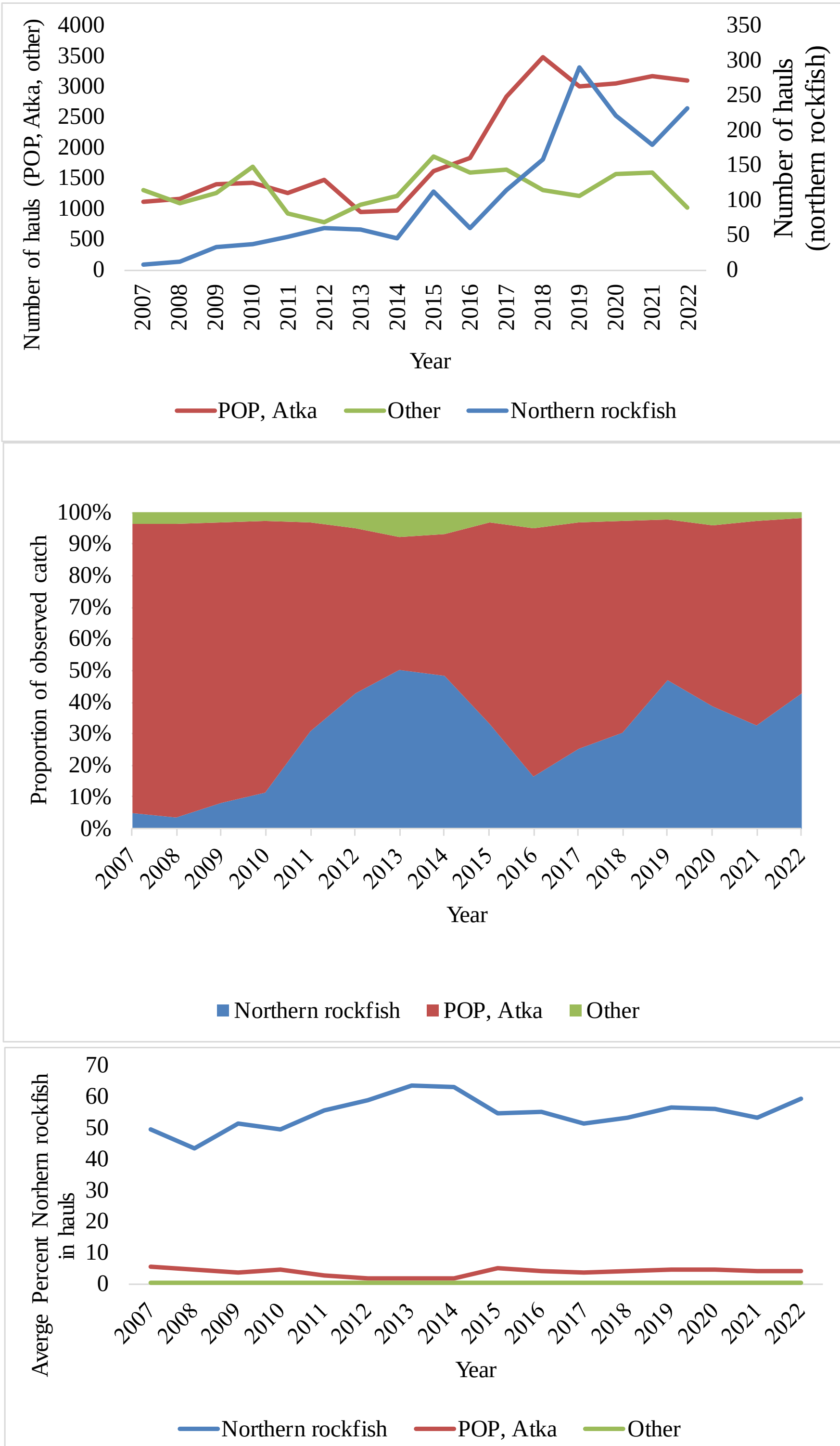



Figure 1. Number of tows, (a), percentage of observed catch (b), and average percent northern rockfish caught (c) in observed hauls from 2007 to 2023 (through August 20) by target fishery. Data are from the North Pacific Groundfish Observer Program.

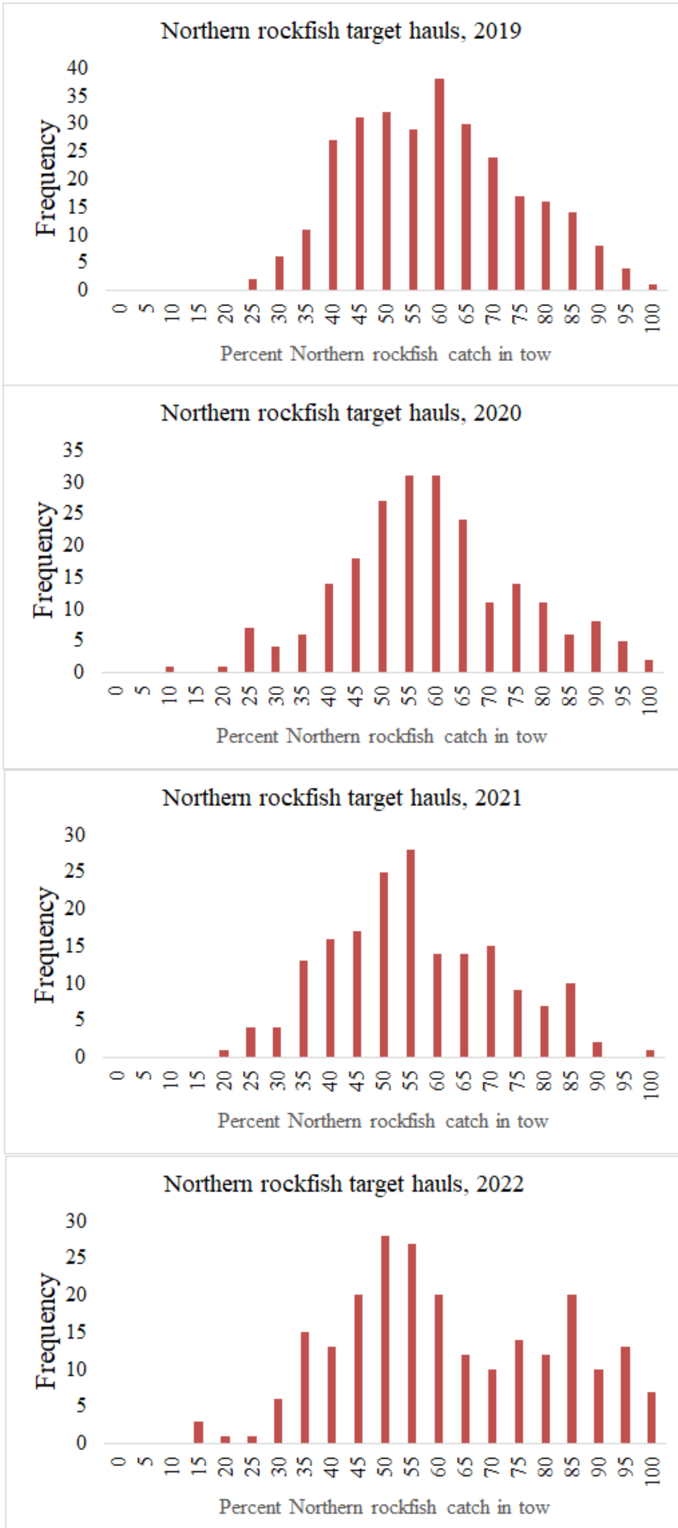



Figure 2. Distribution of the percent northern rockfish in the catch in hauls identified as targeting northern rockfish (based on species composition), from 2018 to 2022. Data are from the North Pacific Groundfish Observer Program.

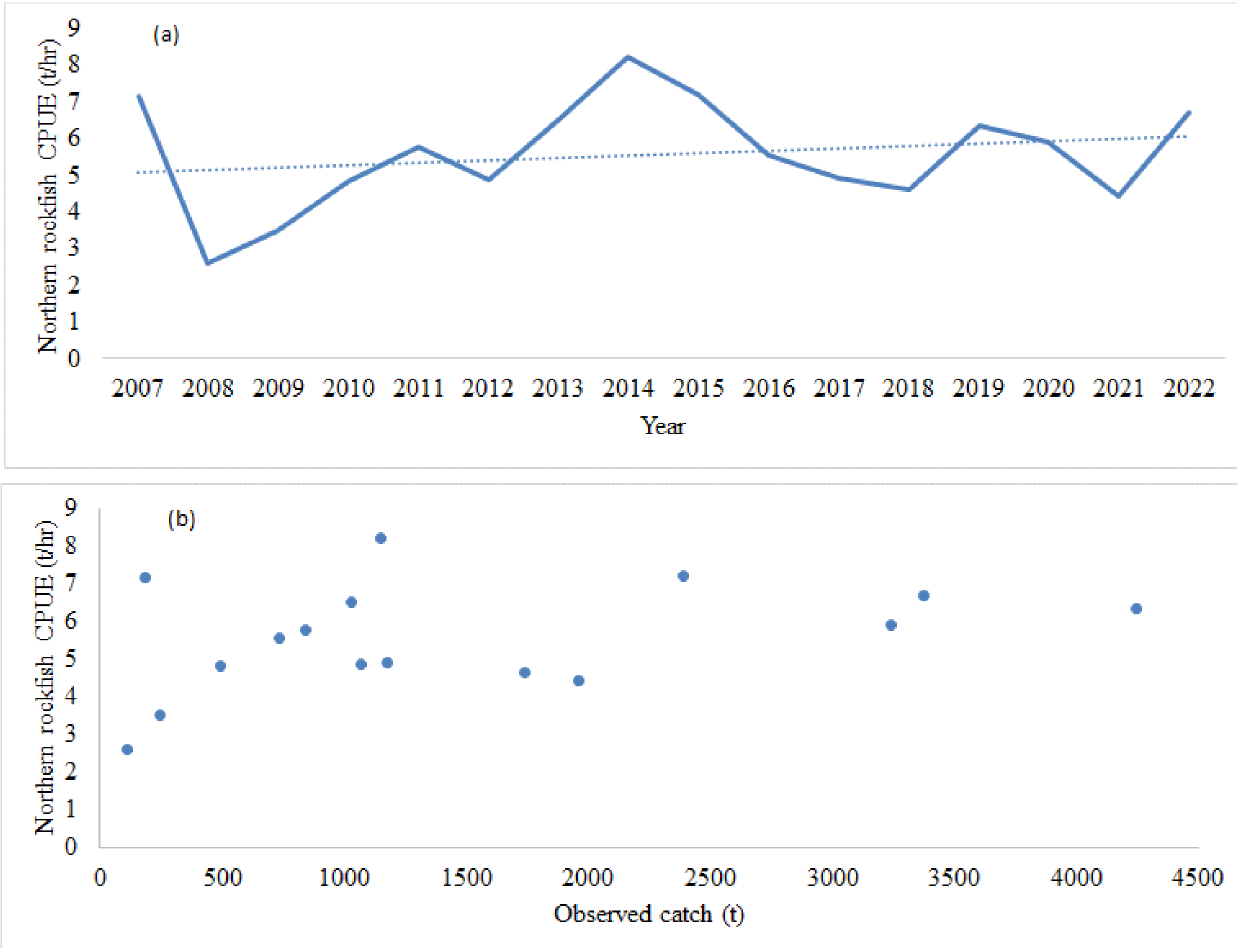



Figure 3. Catch per unit effort of northern rockfish in tows targeting northern rockfish from 2007 to 2022 (a), and plotted against observed catch (b). Data are from the North Pacific Groundfish Observer Program.

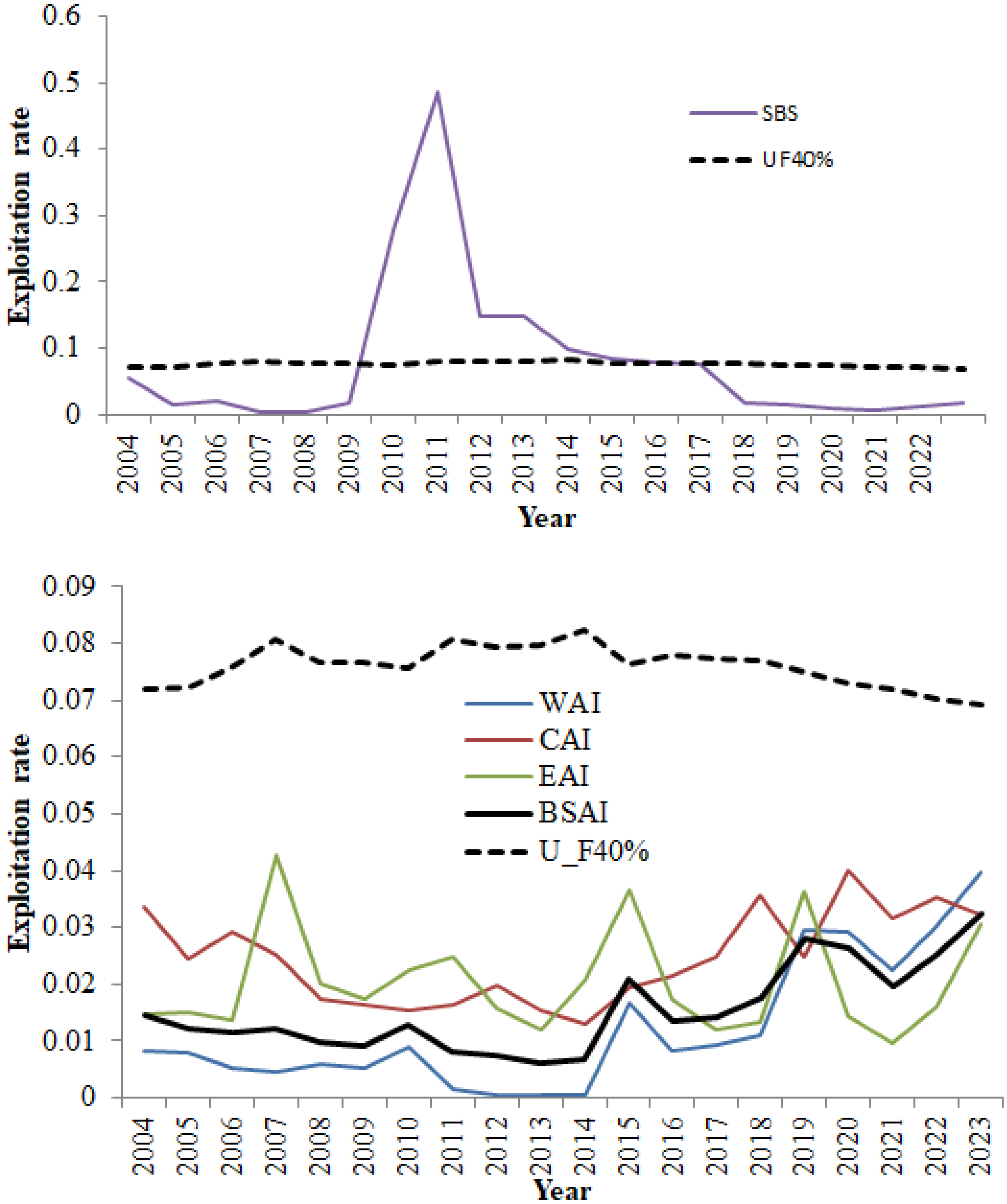
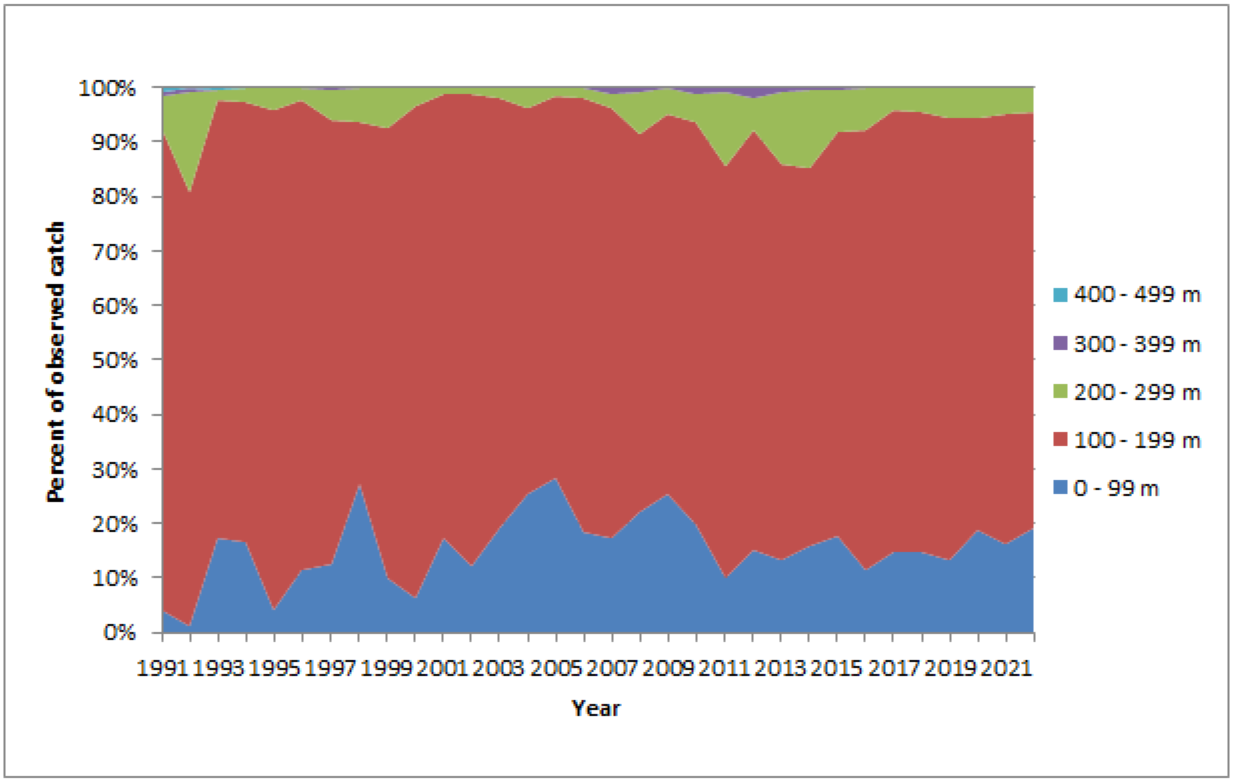



Figure 4. Exploitation rates for northern rockfish. The $U_{F40\%}$ is the exploitation rate for each year that would occur from fishing at $F_{40\%}$, and is a function of the beginning year numbers at age, size at age, and fishing selectivity. The high exploitation rates in the southern Bering Sea (SBS) area result from high variable survey biomass estimates for this area. Exploitation rates for 2023 are preliminary and based on catch through September 26, 2023.



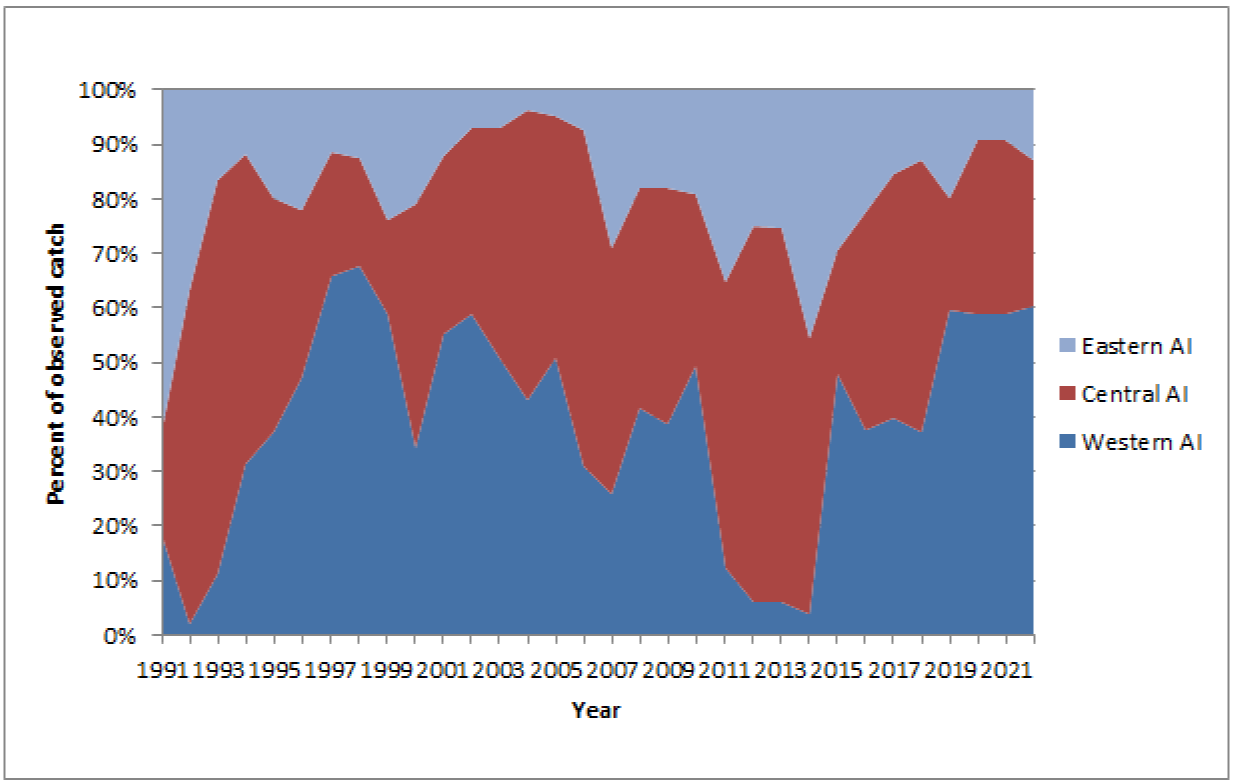




Figure 5. Distribution of observed Aleutian Islands northern rockfish catch (from North Pacific Groundfish Observer Program) by depth zone (top panel) and AI subarea (bottom panel) from 1991 to 2022.

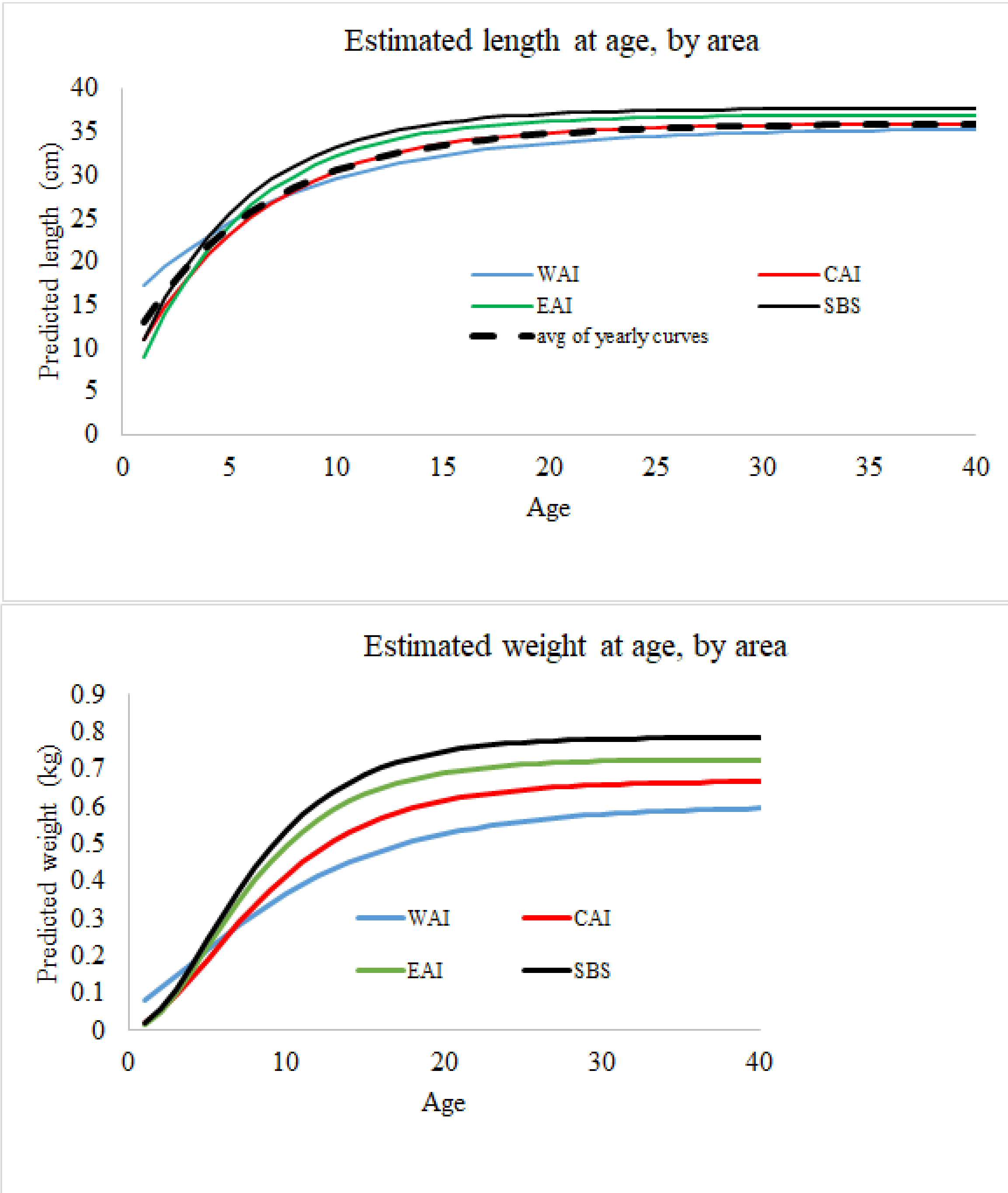



Figure 6. Estimated fishery length and size at age across the AI subareas, from fitted von Bertalanffy curves and length-weight relationships.

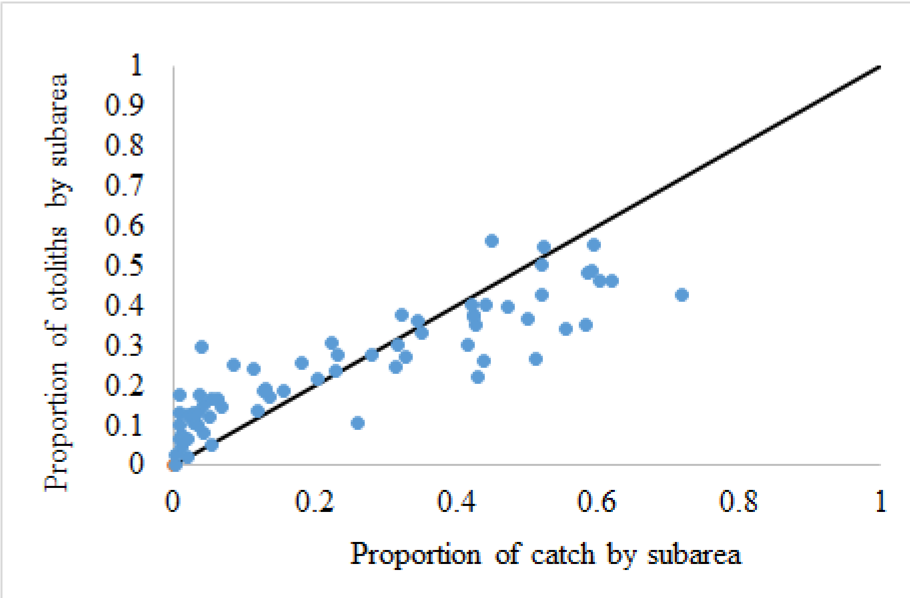



Figure 7. The proportion of the extrapolated fishery catch numbers in AI subarea (i.e., WAI, CAI, EAI, and BS, from North Pacific Groundfish Observer Program) and the proportion of the read otoliths by subarea (from 2000-2021). Random sampling of otoliths from the fishery catch would be expected to generate data near the 1:1 line (in black).

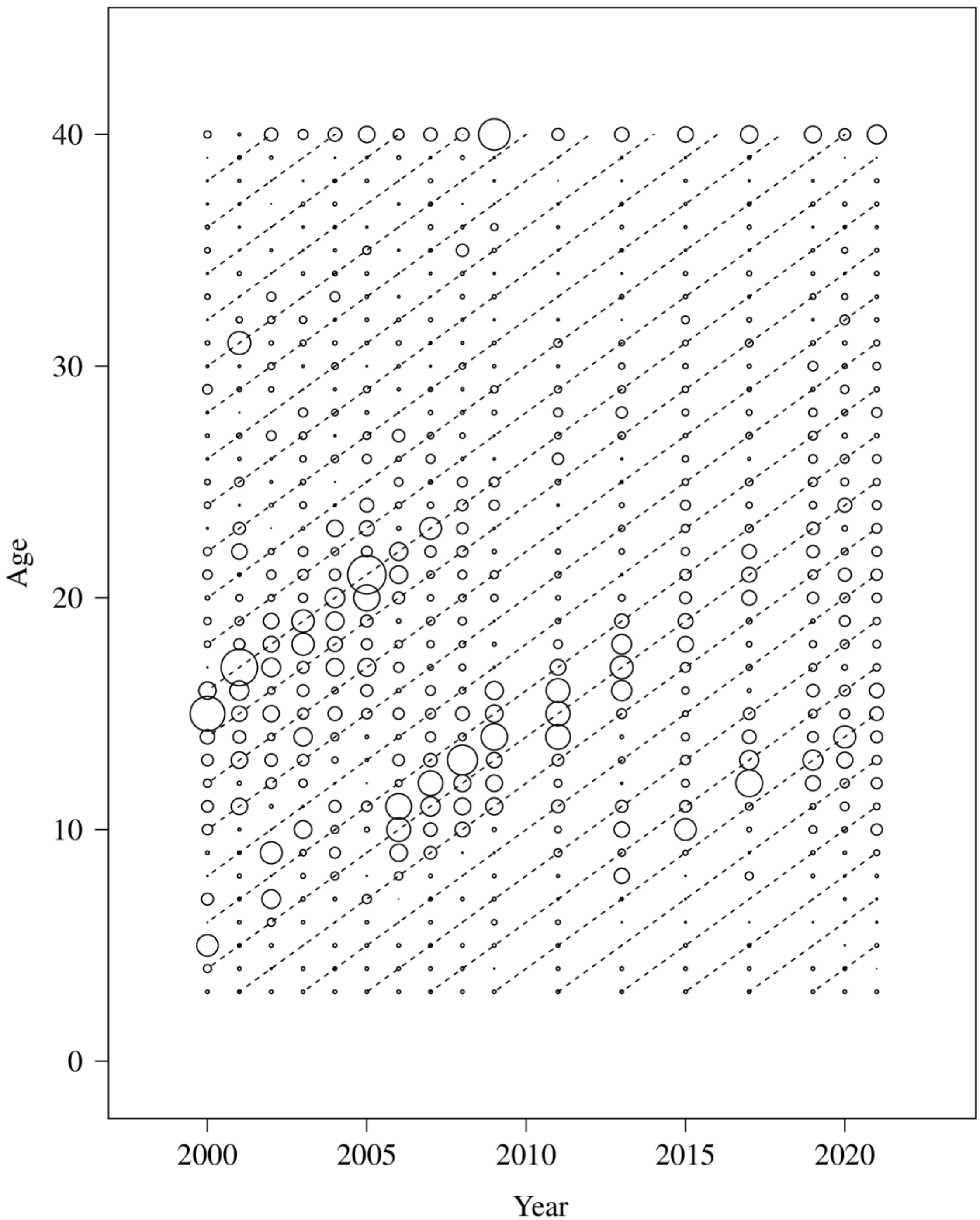



Figure 8. Fishery age composition data for the Aleutian Islands; bubbles are scaled within each year of samples; and dashed lines denote cohorts (beginning at age 3).

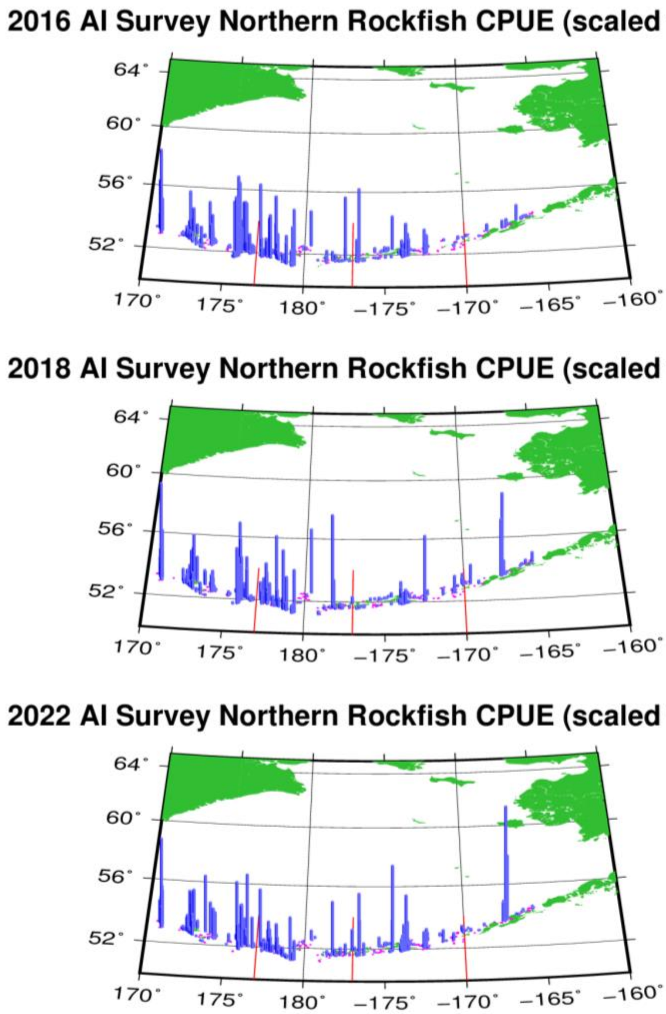



Figure 9. Scaled AI survey northern rockfish CPUE from (square root of kg/km$^2$) from 2016-2022; the red lines indicate boundaries between the WAI, CAI, EAI, and EBS areas.

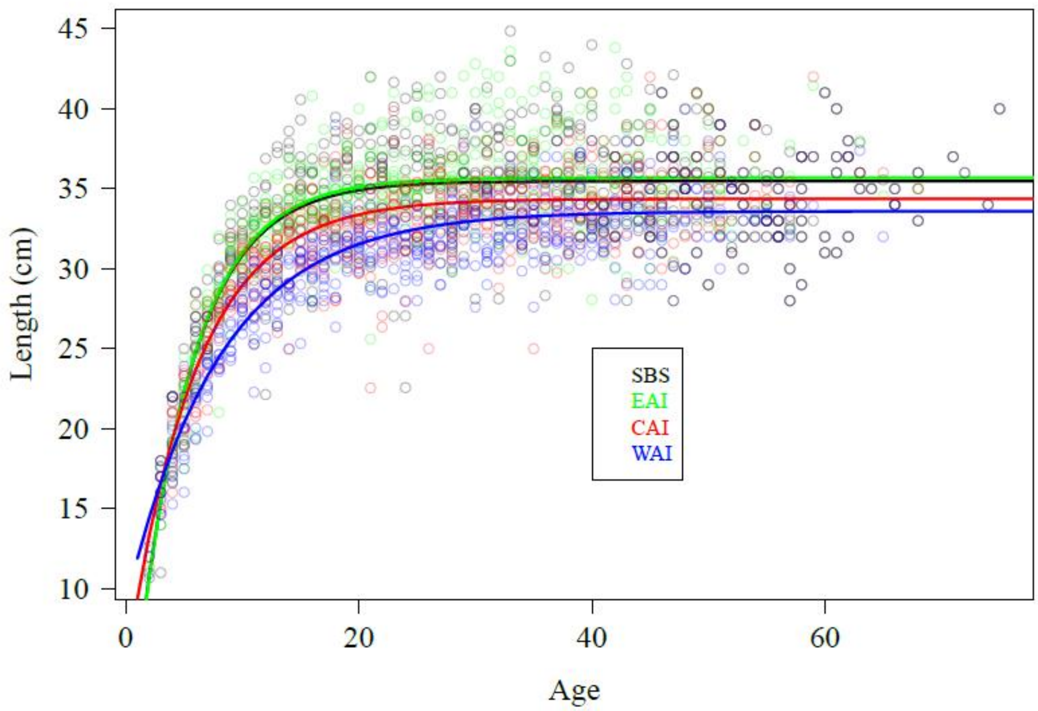



Figure 10. Estimated survey size at age across the AI subareas from fitted von Bertalannfy curves.

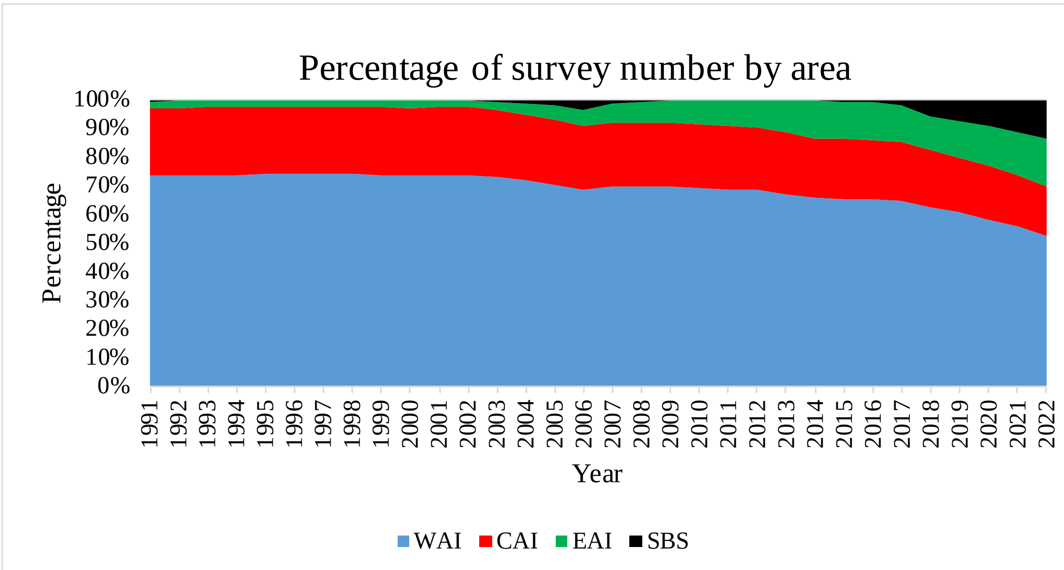



Figure 11. Proportion of northern rockfish survey abundance by area, from a smoother applied to survey estimates form 1991-2022.

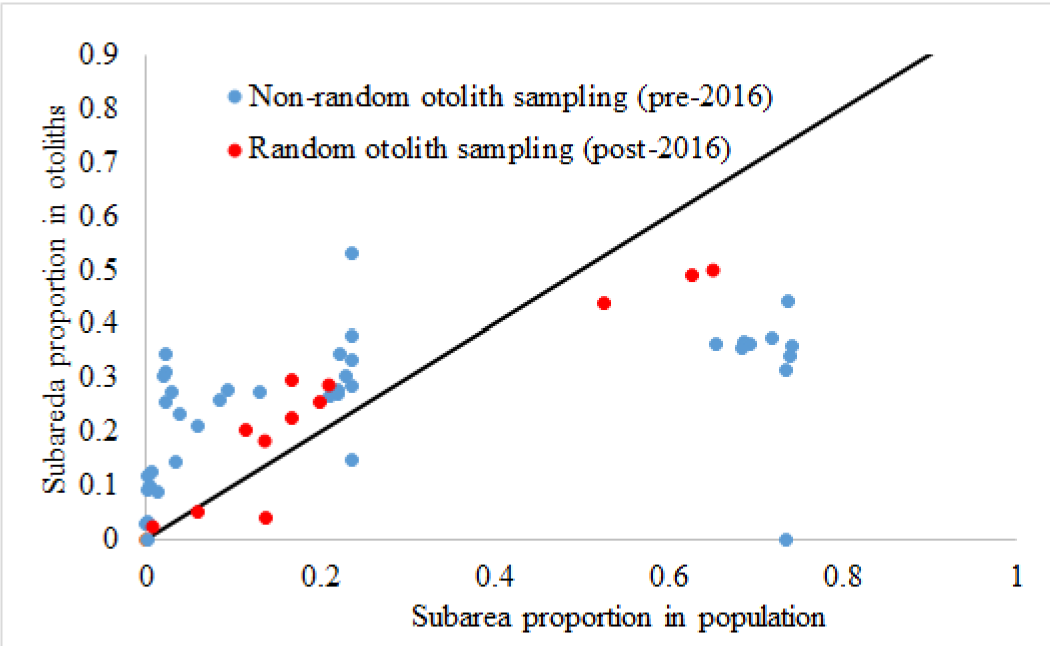



Figure 12. The proportion of the survey population abundance by AI subarea (i.e., WAI, CAI, EAI, and BS) and the proportion of the read otoliths by subarea (from 1991-2022). Random sampling of otoliths occurred since the 2016 survey (shown in red), which would be expected to generate data near the 1:1 line (in black).

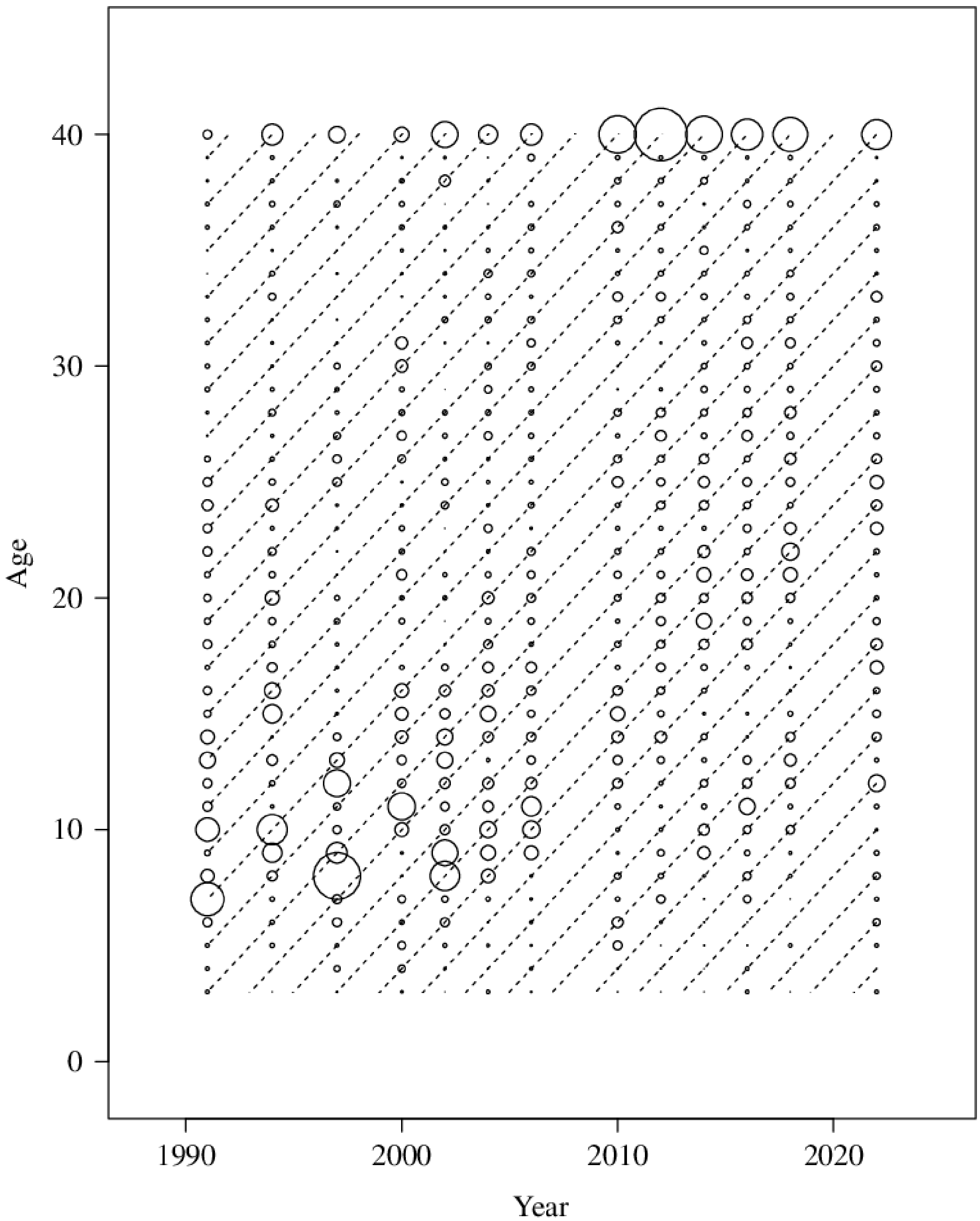



Figure 13. Age composition data from the Aleutian Islands trawl survey; bubbles are scaled within each year of samples; and dashed lines denote cohorts.

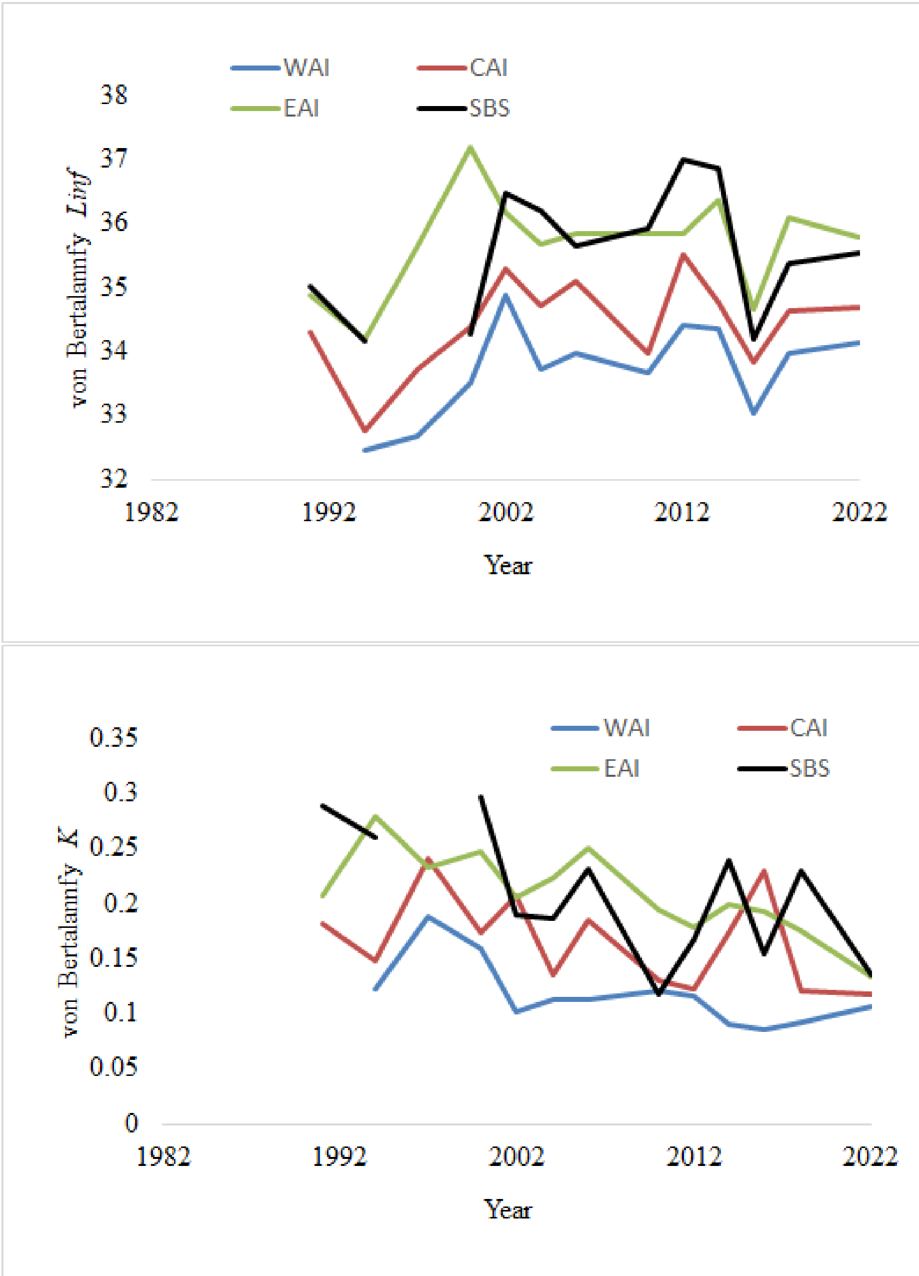



Figure 14. Estimates of von Bertalanffy parameters $L_{inf}$ and $K$ by area and year for the AI trawl survey.

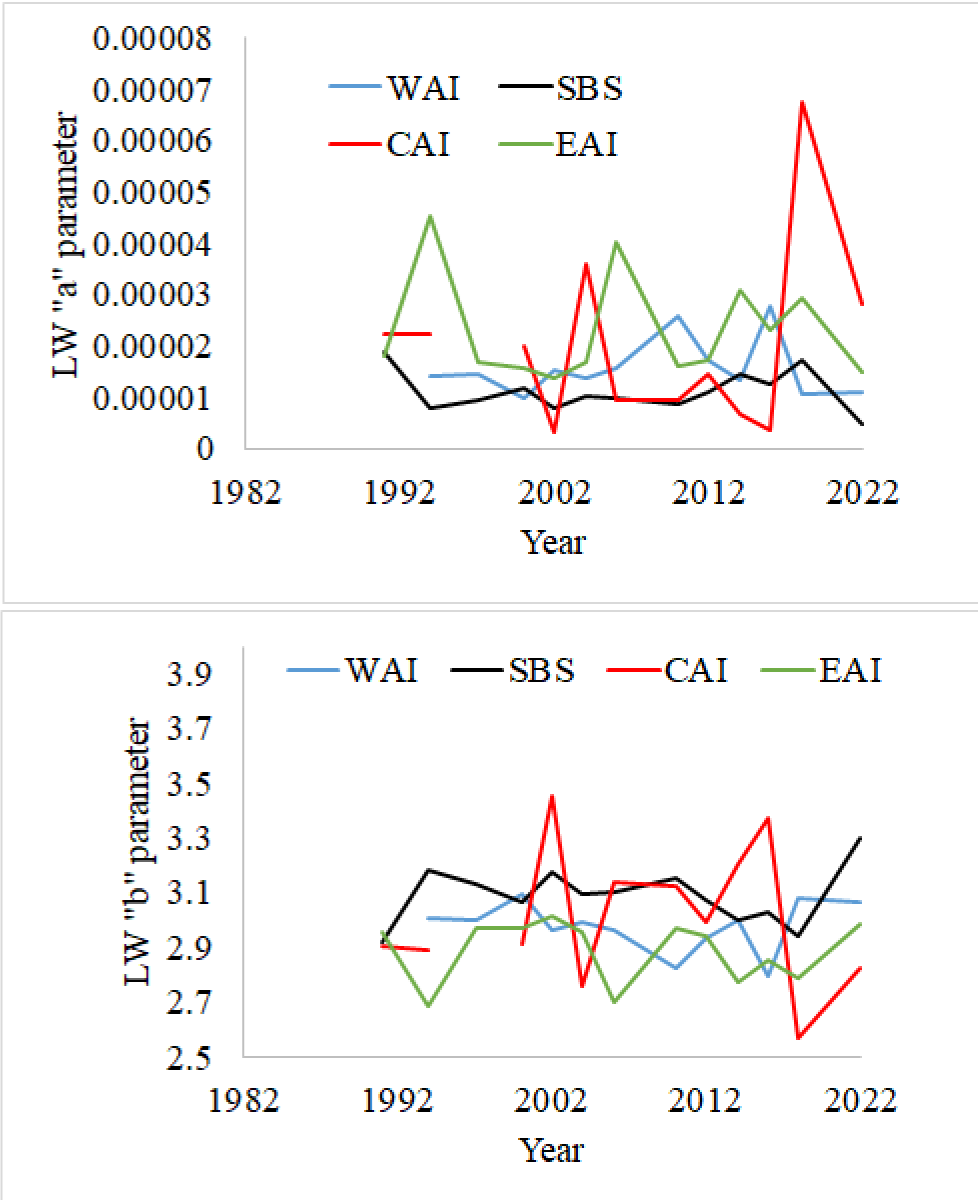



Figure 15. Estimates of the *a* and *b* parameters for the weight-length relationship ($W = aL^b$) by year and area for the AI trawl survey.

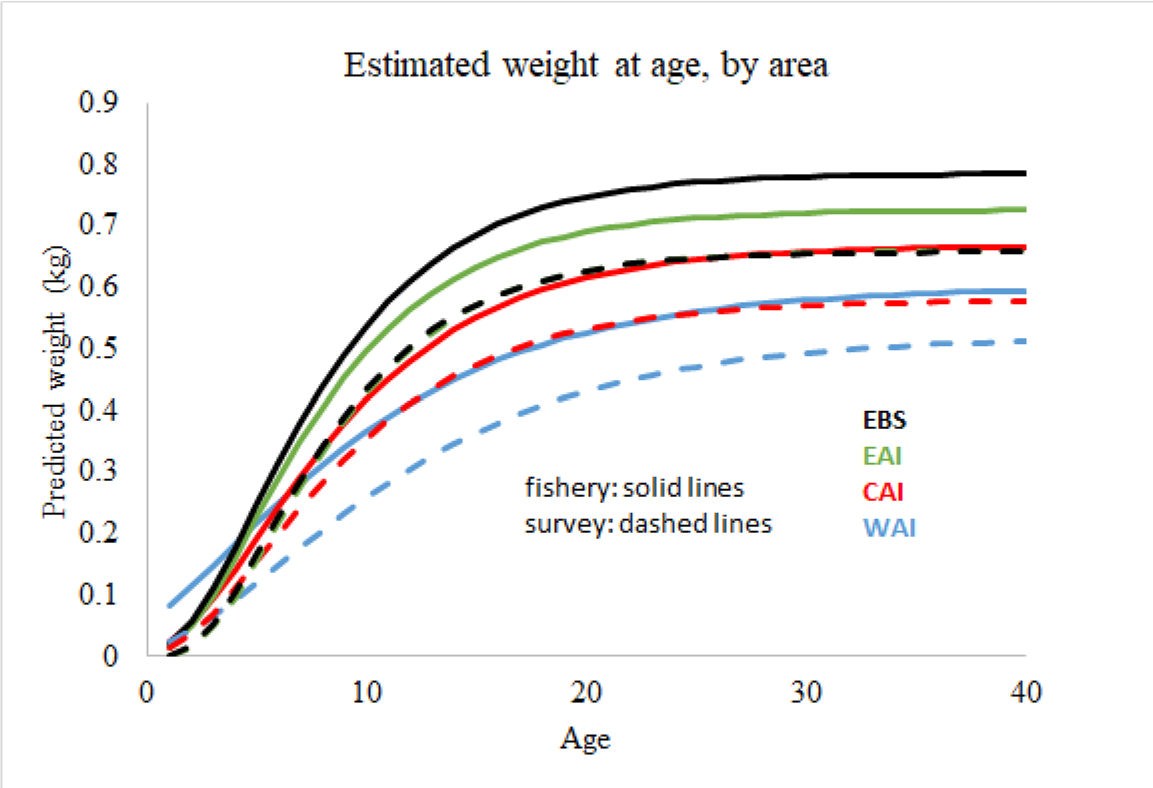



Figure 16. Estimated weights at age by area from the AI trawl survey (dashed lines), combining data across years within each area. The survey size at age for the EAI and EBS are very similar and overlay each other. For comparison, the weight at age in the fishery (solid lines) are also shown.

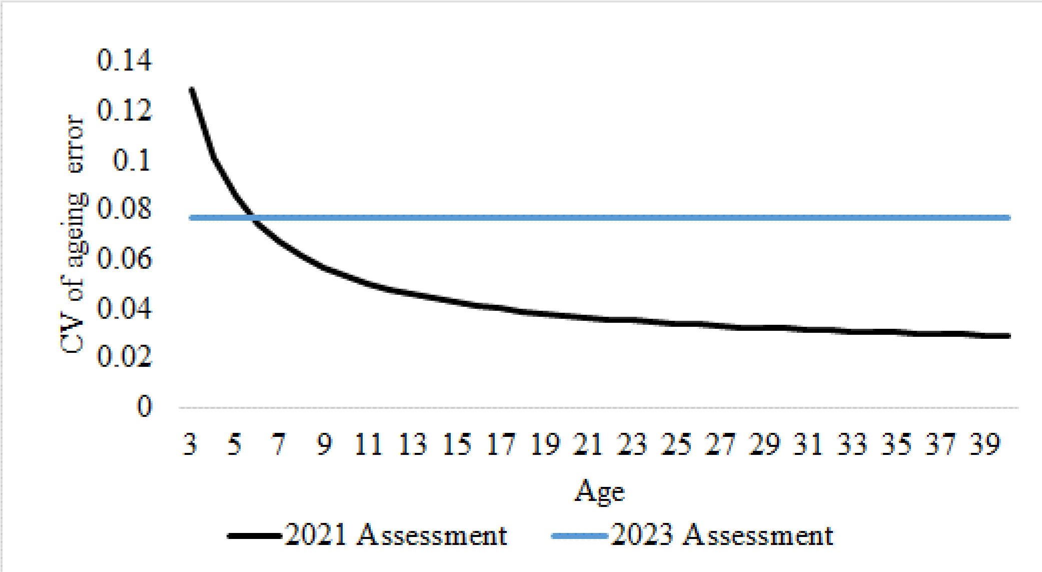



Figure 17. Estimated CV of ageing error in the 2021 and 2023 assessments.

True Age

| Observed Age | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 0.082 | -0.057 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 4 | -0.082 | 0.114 | -0.024 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5 | 0.000 | -0.057 | 0.048 | 0.007 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 6 | 0.000 | 0.000 | -0.024 | -0.014 | 0.031 | 0.006 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 7 | 0.000 | 0.000 | 0.000 | 0.007 | -0.066 | 0.048 | 0.013 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 8 | 0.000 | 0.000 | 0.000 | 0.000 | 0.031 | -0.108 | 0.057 | 0.023 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 9 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.048 | -0.142 | 0.060 | 0.033 | 0.003 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.006 | 0.057 | -0.168 | 0.059 | 0.044 | 0.006 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 11 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.013 | 0.060 | -0.188 | 0.054 | 0.055 | 0.010 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 12 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.023 | 0.059 | -0.203 | 0.046 | 0.064 | 0.014 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 13 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.033 | 0.054 | -0.215 | 0.038 | 0.072 | 0.019 | 0.003 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 14 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.044 | 0.046 | -0.224 | 0.028 | 0.079 | 0.024 | 0.005 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 15 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.055 | 0.038 | -0.231 | 0.018 | 0.084 | 0.030 | 0.007 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 16 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.006 | 0.064 | 0.028 | -0.236 | 0.007 | 0.088 | 0.035 | 0.010 | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 17 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.010 | 0.072 | 0.018 | -0.239 | -0.003 | 0.090 | 0.040 | 0.013 | 0.003 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 18 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.014 | 0.079 | 0.007 | -0.241 | -0.012 | 0.091 | 0.045 | 0.015 | 0.005 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 19 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.019 | 0.084 | -0.003 | -0.243 | -0.021 | 0.091 | 0.050 | 0.019 | 0.006 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 20 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.024 | 0.088 | -0.012 | -0.243 | -0.030 | 0.090 | 0.054 | 0.022 | 0.008 | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 21 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.030 | 0.090 | -0.021 | -0.243 | -0.038 | 0.089 | 0.058 | 0.025 | 0.009 | 0.003 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 22 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.035 | 0.091 | -0.030 | -0.242 | -0.046 | 0.086 | 0.061 | 0.028 | 0.011 | 0.004 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 23 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.007 | 0.040 | 0.091 | -0.038 | -0.241 | -0.053 | 0.084 | 0.064 | 0.031 | 0.013 | 0.005 | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 24 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.010 | 0.045 | 0.090 | -0.046 | -0.240 | -0.060 | 0.080 | 0.066 | 0.034 | 0.015 | 0.006 | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 25 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.013 | 0.050 | 0.089 | -0.053 | -0.238 | -0.066 | 0.077 | 0.068 | 0.037 | 0.017 | 0.007 | 0.003 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 26 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.015 | 0.054 | 0.086 | -0.060 | -0.236 | -0.072 | 0.073 | 0.069 | 0.039 | 0.019 | 0.009 | 0.004 | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 27 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.019 | 0.058 | 0.084 | -0.066 | -0.234 | -0.077 | 0.069 | 0.070 | 0.041 | 0.021 | 0.010 | 0.004 | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 |
| 28 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.005 | 0.022 | 0.061 | 0.080 | -0.072 | -0.232 | -0.082 | 0.064 | 0.071 | 0.044 | 0.023 | 0.011 | 0.005 | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 |
| 29 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.006 | 0.025 | 0.064 | 0.077 | -0.077 | -0.230 | -0.086 | 0.060 | 0.071 | 0.046 | 0.025 | 0.013 | 0.006 | 0.003 | 0.001 | 0.001 | 0.000 |
| 30 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.008 | 0.028 | 0.066 | 0.073 | -0.082 | -0.227 | -0.090 | 0.056 | 0.072 | 0.047 | 0.027 | 0.014 | 0.007 | 0.003 | 0.002 | 0.001 |
| 31 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.009 | 0.031 | 0.068 | 0.069 | -0.086 | -0.225 | -0.094 | 0.051 | 0.071 | 0.049 | 0.029 | 0.016 | 0.008 | 0.004 | 0.002 |
| 32 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.011 | 0.034 | 0.069 | 0.064 | -0.090 | -0.222 | -0.097 | 0.047 | 0.071 | 0.051 | 0.030 | 0.017 | 0.009 | 0.005 |
| 33 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.013 | 0.037 | 0.070 | 0.060 | -0.094 | -0.220 | -0.100 | 0.042 | 0.070 | 0.052 | 0.032 | 0.018 | 0.010 |
| 34 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.004 | 0.015 | 0.039 | 0.071 | 0.056 | -0.097 | -0.217 | -0.102 | 0.038 | 0.069 | 0.053 | 0.033 | 0.020 |
| 35 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.005 | 0.017 | 0.041 | 0.071 | 0.051 | -0.100 | -0.215 | -0.105 | 0.034 | 0.068 | 0.054 | 0.035 |
| 36 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.006 | 0.019 | 0.044 | 0.072 | 0.047 | -0.102 | -0.212 | -0.107 | 0.029 | 0.067 | 0.055 |
| 37 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.007 | 0.021 | 0.046 | 0.071 | 0.042 | -0.105 | -0.210 | -0.109 | 0.025 | 0.066 |
| 38 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.009 | 0.023 | 0.047 | 0.071 | 0.038 | -0.107 | -0.207 | -0.111 | 0.021 |
| 39 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.003 | 0.010 | 0.025 | 0.049 | 0.070 | 0.034 | -0.109 | -0.205 | -0.112 |
| 40 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.004 | 0.011 | 0.027 | 0.051 | 0.069 | 0.029 | -0.111 | -0.202 |

Figure 18. Percent different in the assignment of true ages (columns) to observed ages (rows) between the aging error matrices in the 2021 and 2023 assessments. For older true ages (rightmost columns), the 2023 matrix assigns proportionally less fish to the true age (red) and slightly more fish to ages 2-5 years different than the true age (green).

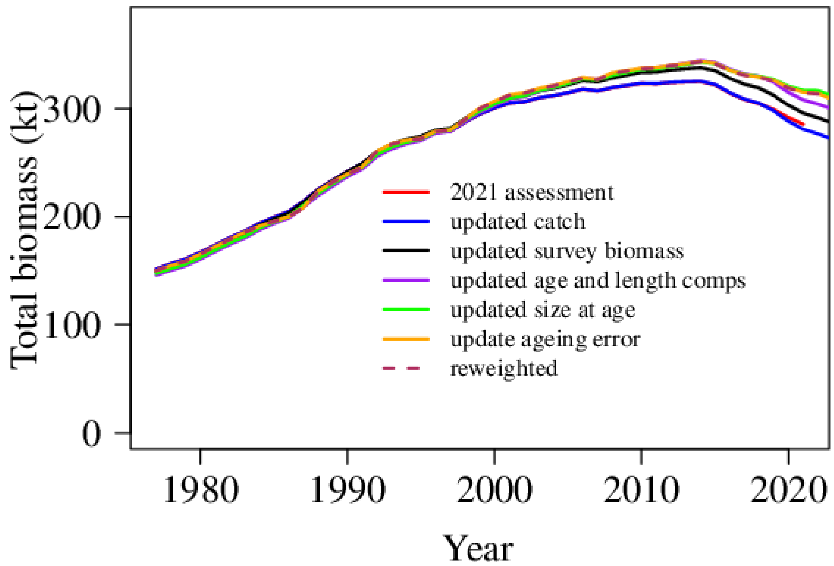



Figure 19. A “bridging” plot showing the sequential effect of updates to the input data on the estimated total biomass, beginning with the final 2021 assessment.

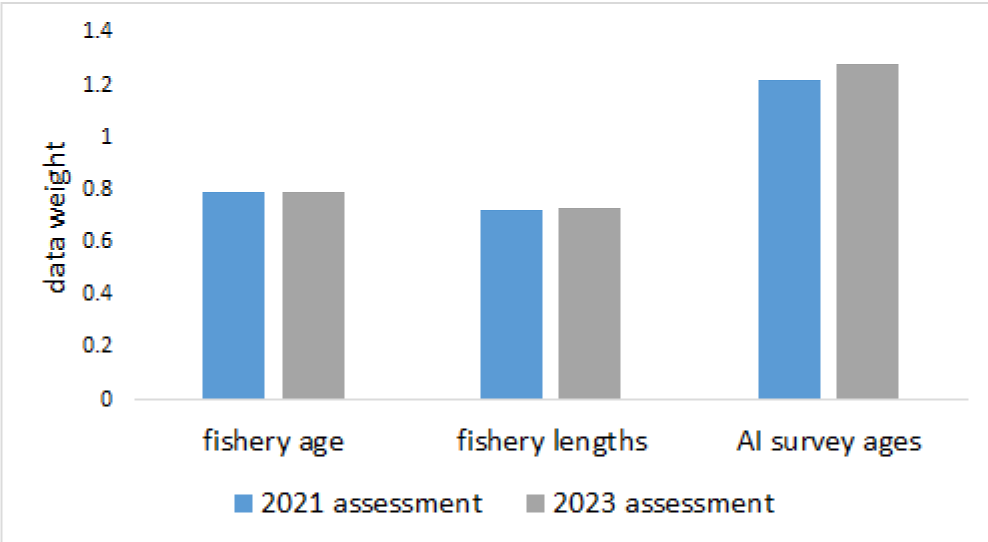



Figure 20. Data weights for the age and length composition data for the 2021 and 2023 assessments.

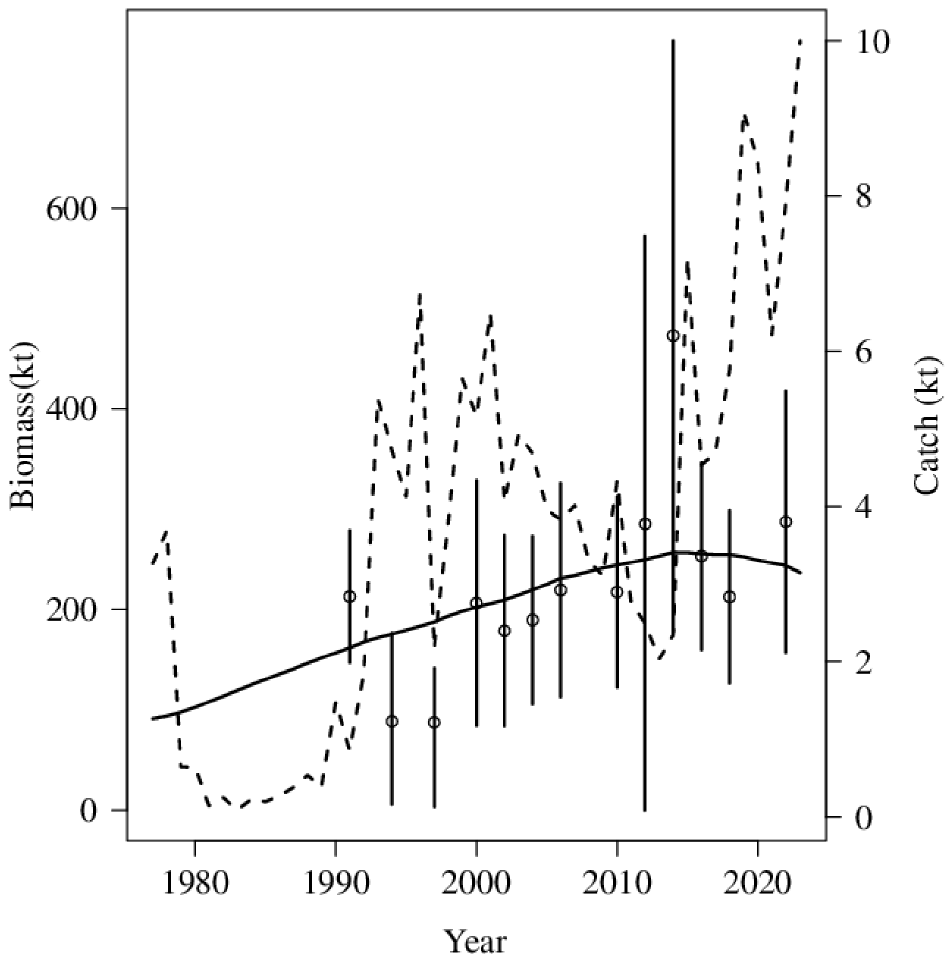



Figure 21. Observed Aleutian Islands survey biomass (data points, ± 2 standard deviations), predicted survey biomass (solid line) and BSAI harvest (dashed line).

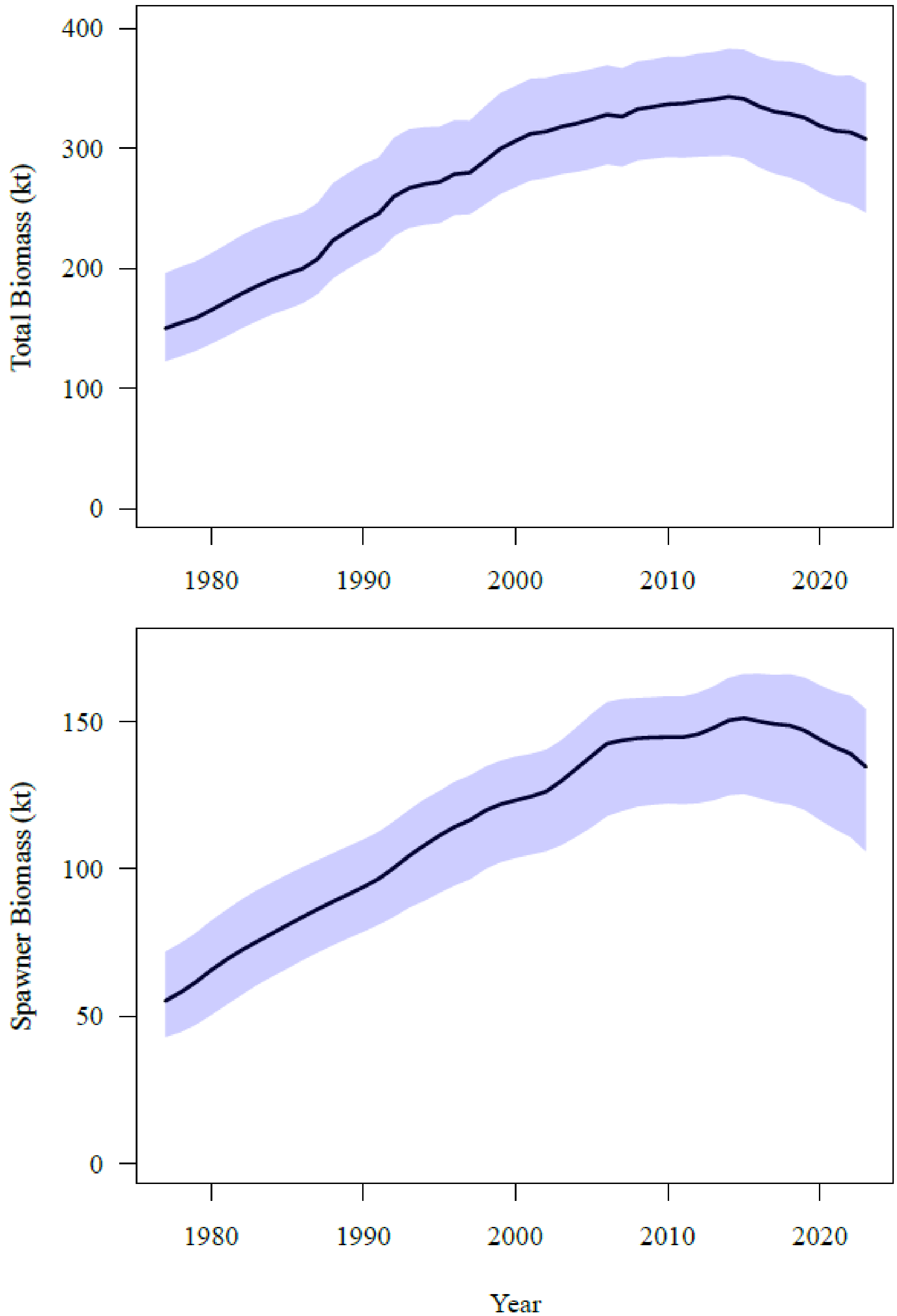



Figure 22. Total and spawning biomass for BSAI northern rockfish with 95% credible intervals from MCMC integration.

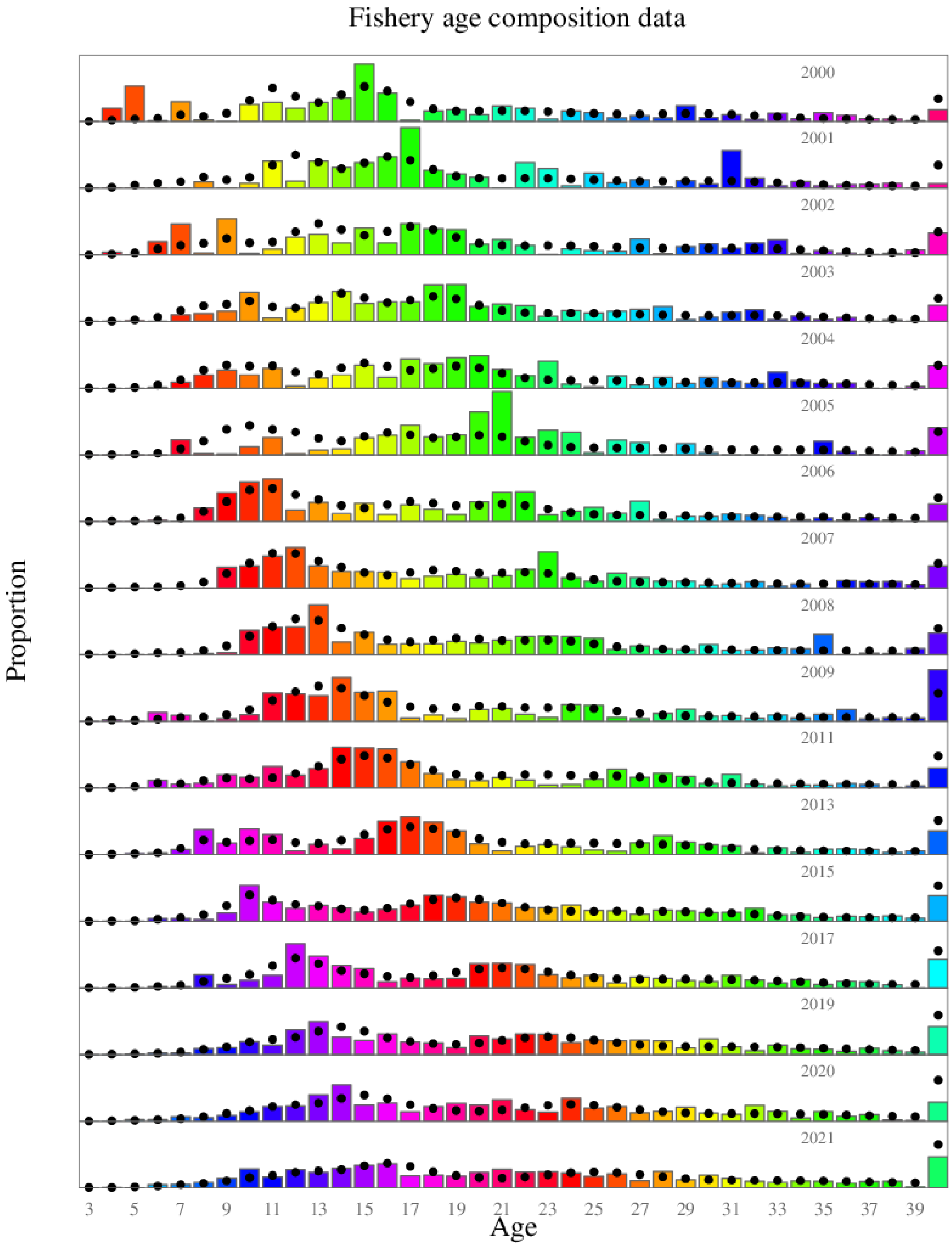



Figure 23. Model fits (dots) to the fishery age composition data (columns) for BSAI northern rockfish. Colors of the bars correspond to cohorts (except for the 40+ group).

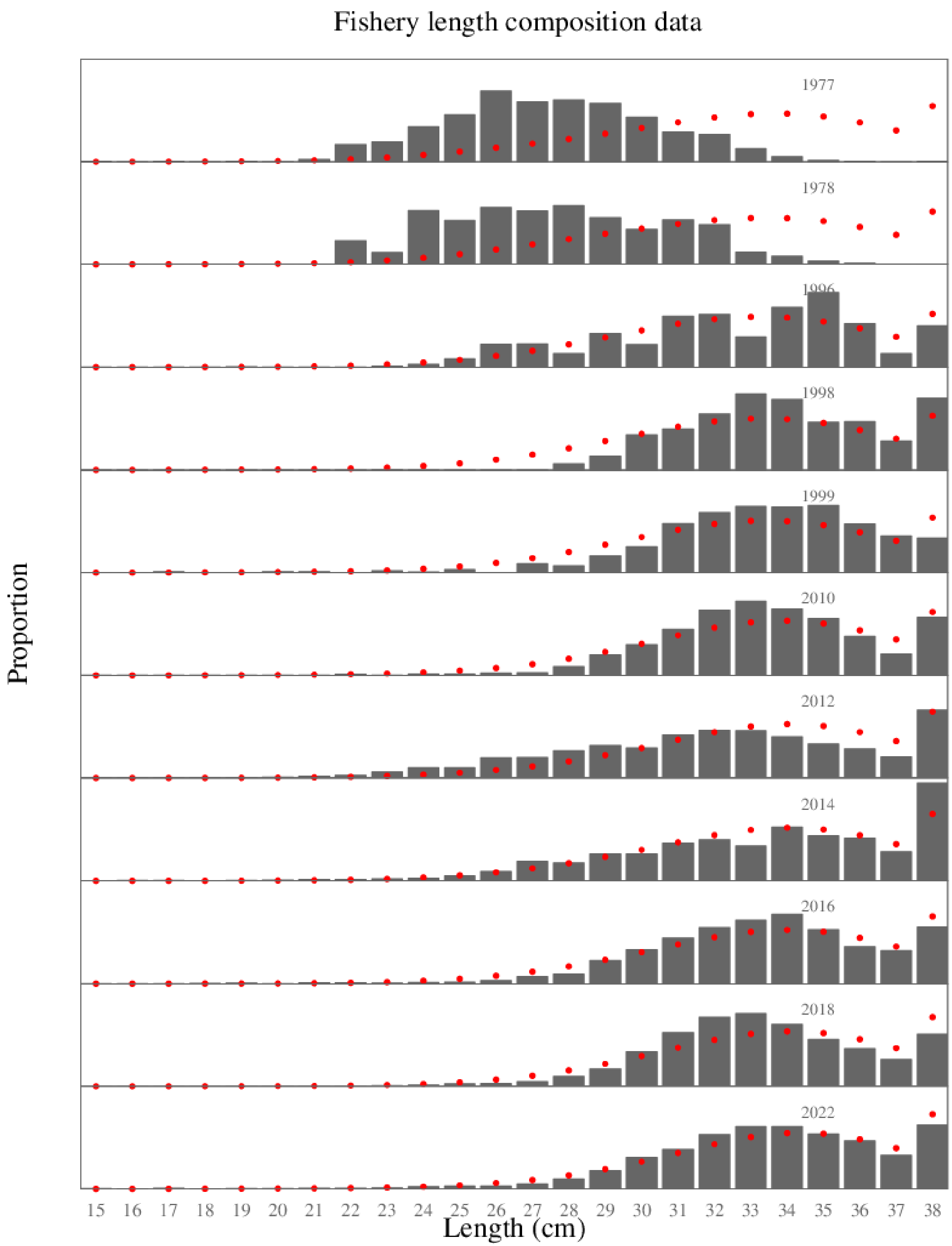



Figure 24. Model fits (dots) to the fishery length composition data (columns) for BSAI northern rockfish.

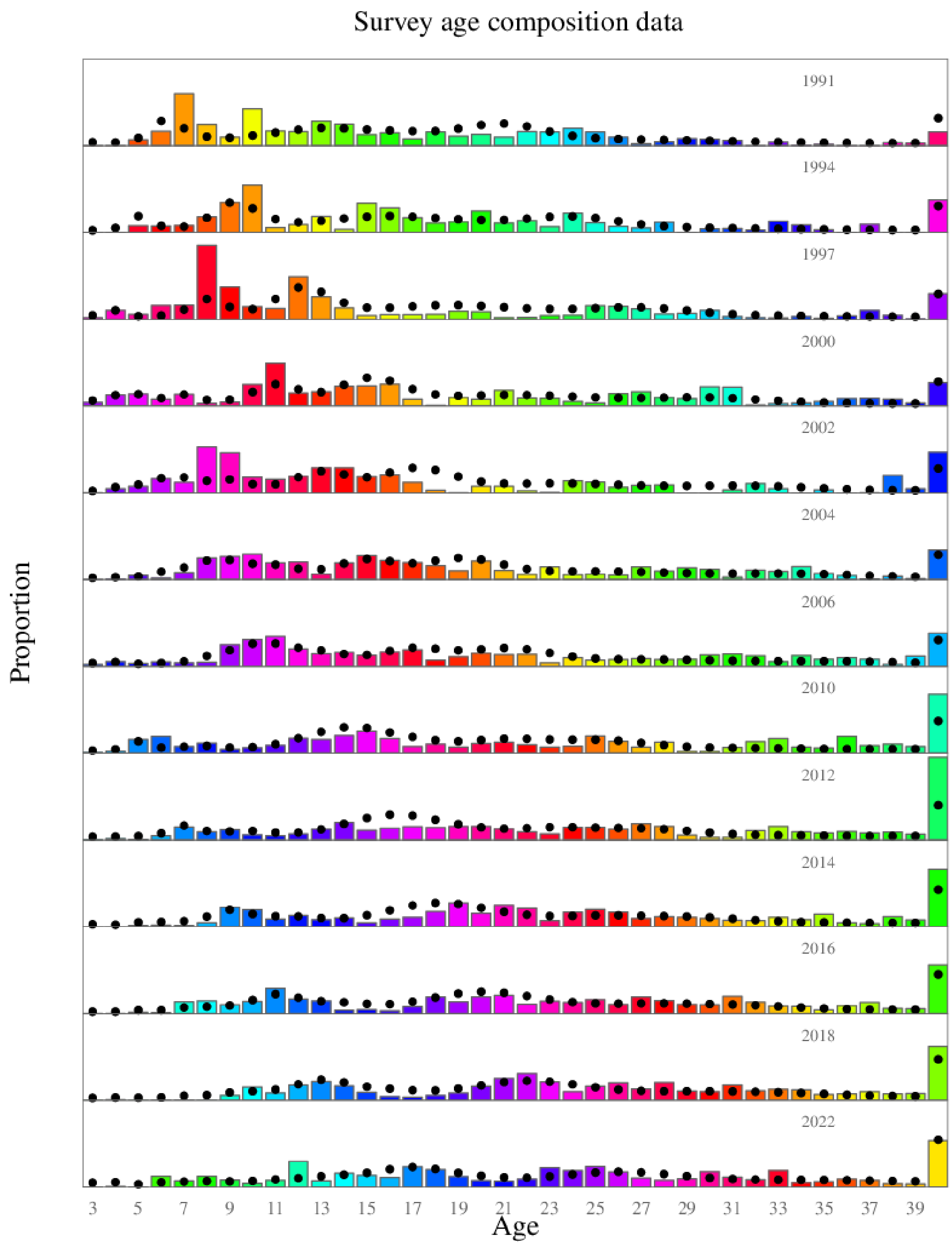



Figure 25. Model fits (dots) to the survey age composition data (columns) for BSAI northern rockfish. Colors of the bars correspond to cohorts (except for the 40+ group).

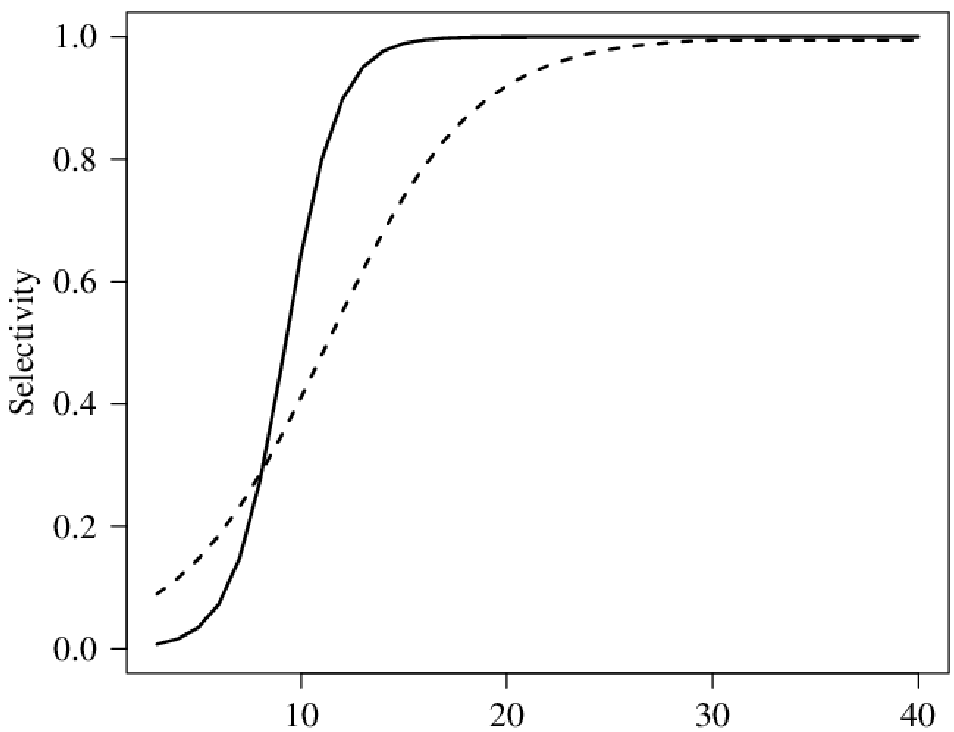



Figure 26. Estimated fishery (solid line) and survey (dashed line) selectivity at age for BSAI northern rockfish.

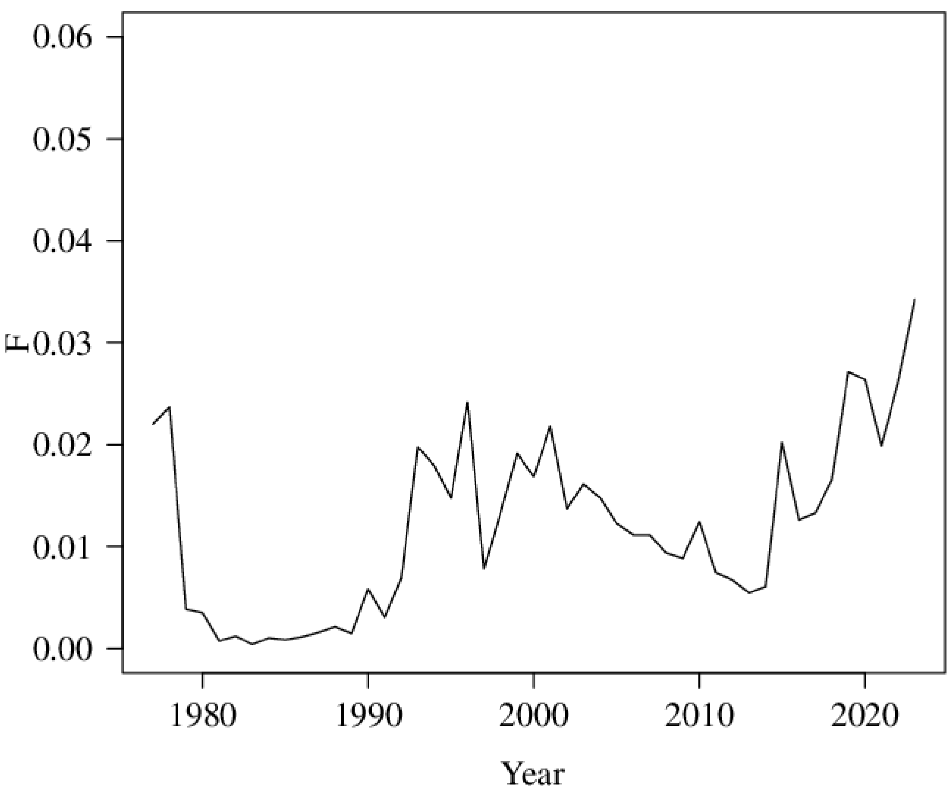



Figure 27. Estimated fully-selected fishing mortality rate for BSAI northern rockfish.

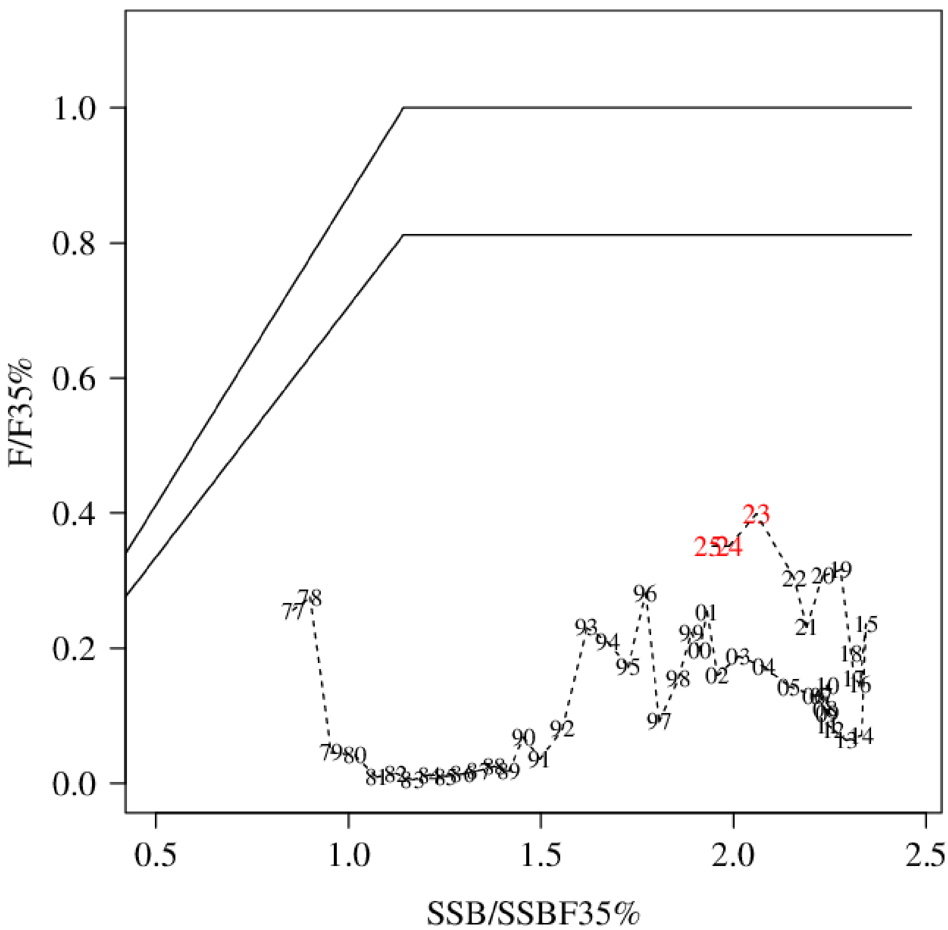



Figure 28. Estimated fishing mortality and SSB from 1977-2025 in reference to OFL (upper line) and ABC (lower line) harvest control rules (values for 2024 and 2025 are based on projections).

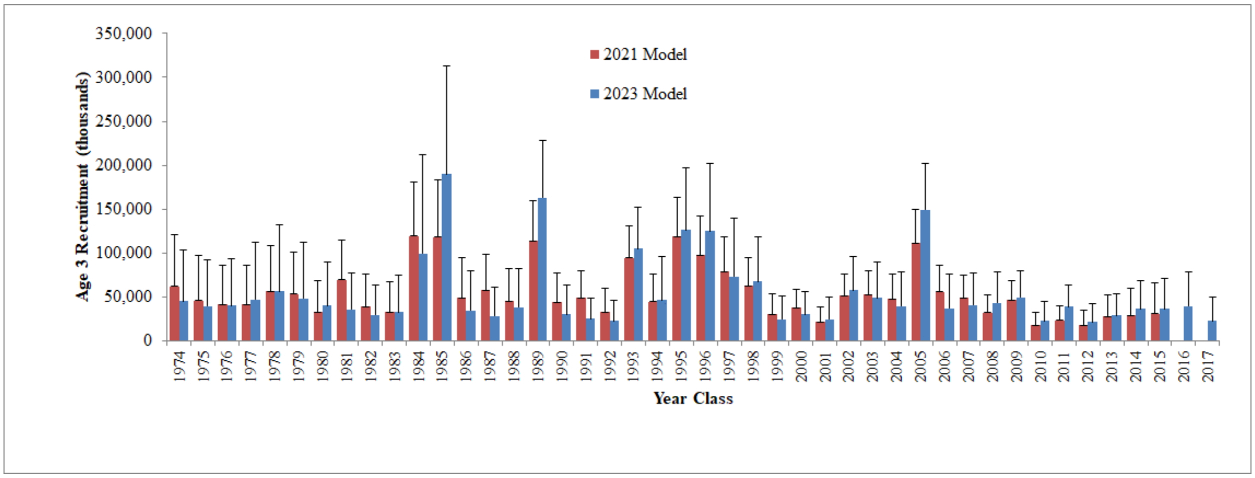



Figure 29. Estimated recruitment (age 3) of BSAI northern rockfish from the 2021 and 2023 assessment models, with 95% CI limits obtained from the Hessian approximation.

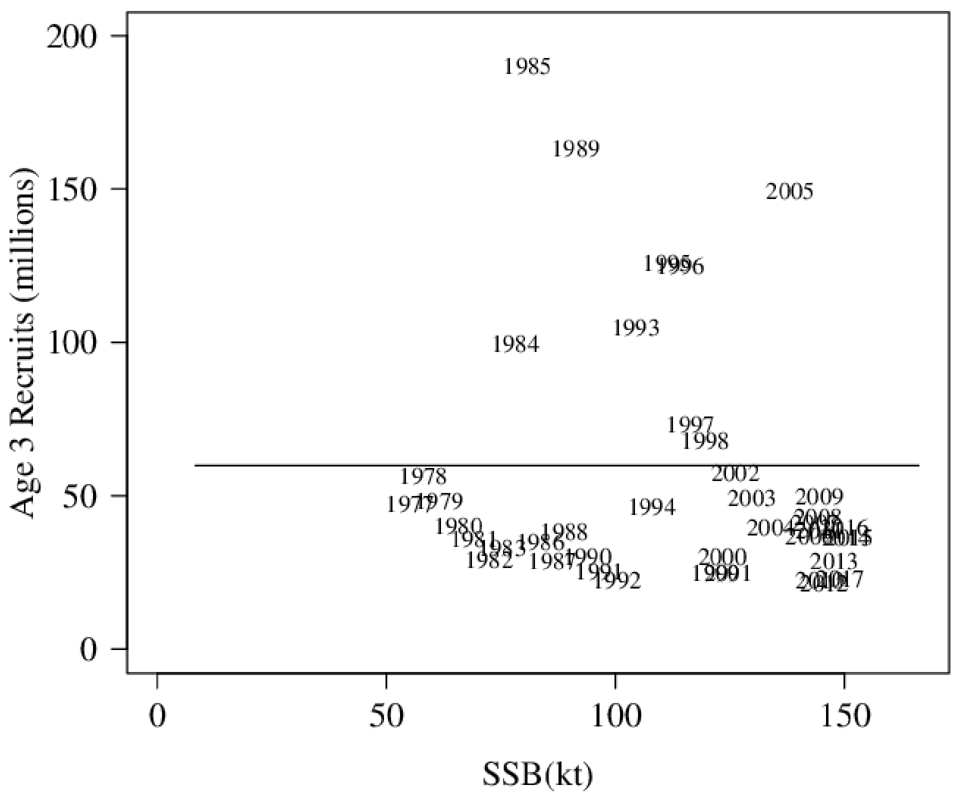



Figure 30. Scatterplot of BSAI northern rockfish spawner-recruit data; labeled values are year classes. The solid line is average recruitment from 1977 to 2017 year classes.

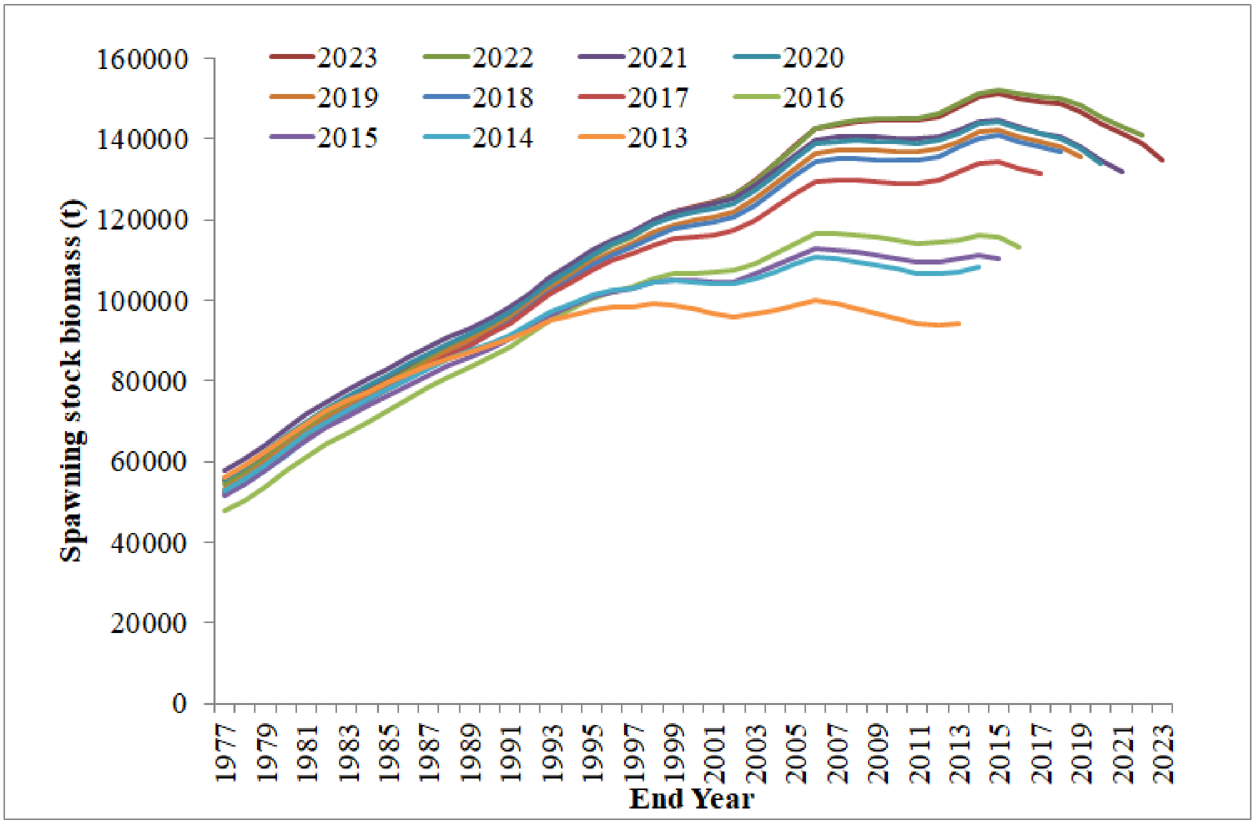



Figure 31. Retrospective estimates of spawning stock biomass for model runs with end years of 2013 to 2023.

# Appendix A. Supplemental Catch Data.

In order to comply with the Annual Catch Limit (ACL) requirements, non-commercial removals that do not occur during directed groundfish fishing activities are reported (Table A1). This includes removals incurred during research, subsistence, personal use, recreational, and exempted fishing permit activities, but does not include removals taken in fisheries other than those managed under the groundfish FMP. These estimates represent additional sources of removals to the existing Catch Accounting System estimates. For BSAI northern rockfish, these estimates can be compared to the trawl research removals reported in previous assessments. BSAI northern rockfish research removals are small relative to the fishery catch. The majority of removals are taken by the Alaska Fisheries Science Center's (AFSC) biennial bottom trawl survey which is the primary research survey used for assessing the population status of BSAI northern rockfish. The annual amount of northern rockfish captured in research longline gear has not exceeded 0.07 t. Total removals ranged between 0 t and 140 t between 2010 and 2022, which did not exceed 1.6% of the ABC in these years.

Appendix Table A1. Removals of BSAI northern rockfish from activities other than groundfish fishing from 1977-2022. Trawl and longline include research survey and occasional short-term projects.

| Year | Source | Trawl | Longline |
|---|---|---|---|
| 1977 | NMFS-AFSC survey databases | | |
| 1978 | | 0.000 | |
| 1979 | | 0.012 | |
| 1980 | | 3.576 | |
| 1981 | | 0.059 | |
| 1982 | | 0.898 | |
| 1983 | | 29.285 | |
| 1984 | | 0.095 | |
| 1985 | | 0.021 | |
| 1986 | | 56.895 | |
| 1987 | | 0.168 | |
| 1988 | | 0.130 | |
| 1989 | | 0.062 | |
| 1990 | | 0.740 | |
| 1991 | | 15.470 | |
| 1992 | | 0.077 | |
| 1993 | | 0.001 | |
| 1994 | | 13.155 | |
| 1995 | | 0.015 | |
| 1996 | | 0.001 | 0.034 |
| 1997 | | 17.728 | |
| 1998 | | 0.252 | 0.004 |
| 1999 | | 0.089 | |
| 2000 | | 39.883 | 0.002 |
| 2001 | | 0.038 | 0.006 |
| 2002 | | 36.657 | 0.011 |
| 2003 | | 0.124 | 0.002 |
| 2004 | | 56.763 | 0.005 |
| 2005 | | 0.002 | 0.002 |
| 2006 | | 41.112 | 0.059 |
| 2007 | | 0.172 | 0.008 |
| 2008 | | 0.026 | 0.008 |
| 2009 | | 0.005 | 0.023 |
| 2010 | AKFIN database | 50.354 | 0.000 |
| 2011 | | 140.163 | 0.014 |
| 2012 | | 89.765 | 0.010 |
| 2013 | | 0.014 | 0.000 |
| 2014 | | 69.154 | 0.000 |
| 2015 | | 0.010 | 0.000 |
| 2016 | | 52.211 | 0.069 |
| 2017 | | 0.043 | 0.004 |
| 2018 | | 49.451 | 0.000 |
| 2019 | | 0.021 | 0.000 |
| 2020 | | 0.000 | 0.000 |
| 2021 | | 0.050 | 0.041 |
| 2022 | | 53.261 | 0.008 |